

COASTAL FLOOD HAZARDS AND RESPONSES IN PUERTO RICO:

AN OVERVIEW

Prepared by:

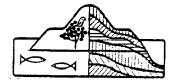
Department of Natural Resources, Planning Area

and

Ralph M. Field and Associates, Consultant

FEBRUARY 1980

Financial assistance provided in part by the Coastal Zone Management Act of 1972, administered by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration.



DEPARTMENT OF NATURAL RESOURCES Coastal Management Program

ACKNOWLEDGEMENTS

Numerous staff members of Commonwealth and Federal agencies contributed greatly to this project, through granting interviews, supplying data, and reviewing drafts of this report. The project staff appreciates the valuable assistance offered by all those individuals and extends special thanks to Robert Calvesbert - U.S. National Weather Service; Emilio Colón - U.S. Army Corps of Engineers; Rafael Torres García - Puerto Rico Department of Transportation and Public Works; Karl Johnson - U.S. Geological Survey; Antonio Munera - State Civil Defense Agency; Boris Oxman - Puerto Rico Planning Board.

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\$ 13 650 0 Environmental impact analysis 'z Puerto Rico. %

\$ 14 650 0 Floods 'z Puerto Rico. %

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STATEMENT OF THE SECRETARY

The Department of Natural Resources, through the Coastal Management Program, has an ongoing project on Coastal Hazards Management intended to reduce future flood losses in Puerto Rico. This document is one of three types of reports being produced under this project:

- Coastal Flood Hazards and Responses in Puerto Rico: An Overview.

 This document provides information of a fairly general, but comprehensive nature. The Overview will provide the reader with an overall understanding of the nature of the coastal flood hazards problem and what is being done to resolve it. It will enable the reader to quickly get a clear idea of how the activities of one agency relate to the efforts of others. The Overview also presents a series of recommendations designed to move Puerto Rico toward development of a more coordinated program of flood hazard management.
- Hazard Mitigation Plans. An islandwide hazard mitigation plan will provide recommendations for actions that can be taken to reduce flood losses throughout Puerto Rico. Hazard mitigation plans for selected floodplains will provide additional detailed recommendations for actions to reduce future flood losses in those areas. Both types of plans will satisfy requirements for hazard mitigation planning imposed by the Federal Emergency Management Agency following a Presidentially declared disaster in September 1979.
- Hazard Management Manual. Directed primarily to technical staffs, the manual will outline procedures for reviewing projects proposed for location within regulated floodplains.

Further information on the Coastal Hazard Management project can be obtained by contacting:

Mr. Gabriel del Toro Assistant Secretary for Planning Department of Natural Resources Box 5887 Puerta de Tierra Station San Juan, Puerto Rico 00906

Through the preparation and distribution of these reports and the Department's continuing efforts to implement recommendations they present, we look forward to significantly reducing flood losses in future years.

Fred V. Soltero Harrington

Secretary

INTRODUCTION

Coastal Flood Hazards and Responses in Puerto Rico: An Overview is the first of several reports on coastal flood hazard management being prepared during the implementation phase of the Puerto Rico Coastal Management Program. The Puerto Rico Coastal Management Program, prepared during 1974 through 1978, contained a brief survey of coastal hazards, including flooding and flood-related erosion. The major findings of that report are:

- About 200,000 cuerdas in the coastal plain are subject to flooding
- Urbanization is increasing the area subject to flooding along with the number of people and value of property subject to flooding
- Because of Puerto Rico's topography and climate, flooding will continue to be a problem
- Nevertheless, flooding and flood damage can be reduced by governmental action of several kinds:
 - Flood control measures can be taken, including the construction of flood control works.
 - Other measures -- such as reforestation of upland watersheds and the adoption of regulations to bar excessive grading and paving -- can help reduce the rate of storm water runoff.
 - People who live in floodable areas can be assisted and trained in evacuation and other emergency measures.
 - Policies and regulations can guide urban expansion toward areas that are not floodable.
 - Regulations can prohibit new structures in floodable areas or require them to be flood-protected.

Following approval of the Coastal Management Program in 1978, the Department of Natural Resources decided that it should continue to address the problems of coastal flood hazards through the implementation phase of the Coastal Management Program. The Department decided to undertake three principal

activities: first, perform a more thorough evaluation of flood hazard problems and responses so that the existing program of flood hazard management could be clearly set forth, deficiencies identified and recommendations for improvement made; second, prepare more detailed hazard mitigation plans for selected areas of the coast and for the entire island; and third, develop technical guidance materials that would aid agency professional staff in reviewing projects proposed for development within floodable areas.

This Overview is designed primarily for use by governmental agencies — to provide a fairly quick, overall understanding of the nature of the coastal flood hazard problem and what is being done about it. Since coastal flooding is, to some extent, caused by activities outside the coastal zone, it was recognized at the beginning of the project that a document addressing only the coastal zone would be impractical. Consequently, although this document is focused on the coastal zone, much of it applies to flood hazards throughout Puerto Rico.

The Overview consists of three sections:

- I. Flood Hazards of Puerto Rico's Coastal Zone: describes the nature of the coastal flood hazard, the history of flooding, and areas subject to flooding.
- II. Response to the Flood Hazard: describes what is being done about the problem in three broad categories -- reducing susceptibility to flood damages and disruption, control of flooding, and minimizing the impact of flooding on individuals and the community.
- III. Moving Toward a Coordinated Program of Flood Hazard Management: identifies areas in which the response to the coastal flood hazard can be improved. Some of these recommendations are already in process; others are to be acted on by the Department of Natural Resources or other agencies in the future.

A Supplement provides a preliminary account of damages and responses to flooding caused by Hurricane David and Tropical Storm Frederic during August -September 1979.

PART I. FLOOD HAZARDS OF PUERTO RICO'S COASTAL ZONE

Types of Flood Hazards in the Coastal Zone

Flood hazards in Puerto Rico reflect the island's tropical weather conditions, topography and high population density. Nearly 70 nonnavigable rivers and streams — whose banks and drainage areas are dotted with communities — originate in a central mountain range and rapidly reach the coastal plain. These rivers are narrow, shallow and relatively short (mostly less than 20 miles long), making them highly susceptible to flooding and particularly to flash flooding. Poor drainage and high density of construction in the floodplain, with accompanying high runoff rates, have increased the vulnerability of these areas to flooding. The flooding problem is further aggravated in many urban areas due to inadequate storm drainage systems or poor maintenance of the storm drainage systems and stream channels. Large portions of the coastal plain are also subject to storm surge flooding and erosion from hurricanes and other tropical storms that push seawater onshore, and from heavy coastal sea swells generated by winter storms in the North Atlantic.

FLOOD PRODUCING WEATHER PATTERNS

Flooding results from heavy rains of sufficient intensity and duration to cause more water to flow in a stream channel than the channel can carry, and from waves pushed onto the shore by high tides and winds. Meteorological causes of heavy rains and winds that induce flooding in Puerto Rico are discussed briefly below.

Tropical Cyclones - The term "cyclone" applies to any atmospheric system which has a counterclockwise rotation (in the northern hemisphere) and where the barometric pressure is lowest at the

Rapid rises in the lower floodplains following heavy rainfall in the upper watershed.

center. The term applies to storms of small or great intensity, covering an area of at least 50 miles and often as much as a thousand miles. Cyclones can form outside as well as within the tropical zones.

Tropical cyclones are defined in terms of wind speeds and atmospheric pressure patterns (not rainfall intensity):

- Hurricane a tropical cyclone with winds of 75 miles per hour or more.
- Tropical storm a cyclone with a wind force of 39 mph or more. (Many disturbances in this category, although not of hurricane intensity, have caused severe flooding in Puerto Rico.)
- Tropical depression a cyclone with winds equal to or less than 38 mph.
- Tropical disturbance a cyclone with little or no rotary circulation at the surface, and no strong winds. (A common phenomenon in the tropics, this type of disturbance often proceeds a tropical depression, tropical storm or hurricane.)

In the Atlantic, the tropical cyclone season is principally from June through October. Out of season storms have occurred, such as one that passed near Puerto Rico during January 1951. The distribution of tropical cyclones affecting Puerto Rico during the period 1879-1979 is shown below²:

Some of Puerto Rico's heaviest recorded rainfalls have resulted from tropical cyclones, producing extensive flooding. Examples of greatest observed point rainfall in Puerto Rico resulting from tropical cyclone activity for the period 1899-1976 are shown below:

The only definitely known hurricane formed during the winter season has been
Alice in January 1955, which occurred in the vicinity of the Lesser Antilles.

Historia de Temporales de Puerto Rico 1508-1949, Luis A. Salivia; Lista de Ciclones Tropicales de Puerto Rico, José A. Colón; and Tropical Cyclones Affecting Puerto Rico, Robert J. Calvesbert.

Inches	Duration	Place	Event and Date
6.2	2 hours	Pico del Este	Tropical Storm Eloise September 16, 1975
18.22	12 hours	Naguabo	Tropical Storm San Zacarías September 7, 1910
23.00	24 hours	Adjuntas	Hurricane San Ciriaco August 8, 1899
29.60	48 hours	Adjuntas	Hurricane San Felipe September 13-14, 1928
35.99	5 days	Jayuya	Tropical Depression October 6-10, 1970
42.58	10 days	Jayuya	Tropical Depression October 1-10, 1970

A hurricane or tropical storm need not pass directly over Puerto Rico in order to produce disastrous flooding. A recent example of this is Tropical Storm Eloise of September 1975¹, which paralleled the north coast of Puerto Rico and produced some of the heaviest rainfall recorded on the island as well as serious flooding along the south and southwestern sections. Hurricane Donna of September 1960, which also passed about 80 miles off the north coast, caused tragic flooding in Humacao where 90 people drowned. Most recently, Hurricane David of August 1979 passed 100 miles south of Ponce causing widespread flooding on both the north and south coasts.

Tropical Wave - Another heavy rain-producing weather system in the Caribbean area is the tropical wave, sometimes called the easterly wave. This is essentially a trough of low pressure embedded in the easterly flow of the large high pressure cell located to the north of Puerto Rico (the Azores-Bermuda High). The peak season for these waves is from June through September with a lesser frequency in May, October and November. In the eastern Caribbean there is an average of about two wave passages per week. The weather pattern associated with these waves often varies and must be watched carefully for signs of becoming "unstable" and developing into a hurricane vortex. Heavy rains often follow the passage of the wave (heavy shower and thundershower activity for as much as 200-300 miles behind the pressure trough occur) and many floods have been recorded in their wake.

¹Eloise reached hurricane intensity after it passed Puerto Rico.

The Polar Trough - The polar trough is an axis of low pressure embedded in the prevailing westerlies that lie above the lower level easterly trade winds. It occurs primarily during the winter season and very rarely during the early summer and late fall. The polar trough moves from west to east and can produce heavy rains with associated flooding. Depending on strength and speed of movement, the associated precipitation patterns can range from high intensity localized rains to more general, longer duration light to moderate rainfall. In any event, these systems have the potential to cause serious flood problems, particularly if they become stationary for any length of time just west of Puerto Rico.

Meso-Scale Systems - Intense rainfall and flooding are not always the result of large scale atmospheric systems. A single thunderstorm can produce a serious flash flood if several factors favorable to flooding coincide. For example, a stationary or slow moving thunderstorm, dumping as much as three or more inches of rain in less than three hours over saturated terrain located in a narrow, steeply sloped river basin, can generate a serious flash flood.

Local severe rainstorms can be generated by a number of different atmospheric conditions, including: sea breeze convergence with the prevailing trades just inland from the coast line; counter trade sea
breeze flow on the west coast; localized build-up of cumulus clouds
from inland heating; and convection within an unstable air mass until
a severe thunderstorm is formed. All of these local storms have the
potential to produce flash floods.

FLASH FLOODING

The incidence of flooding of coastal areas by river overflows is not directly related to average annual rainfall on the coast. Most riverine flooding in Puerto Rico is of a flash flood type - developing quickly and also ending rapidly. Typical flash floods occur with little or no rainfall on the coast but with very heavy rainfall in the upper basins.

Compared to the north coast, south coast rivers are more "flashy" because

of their shorter length and steeper slopes. The average length of southern basins is about 14 miles compared to 22 miles for northern rivers. There is an average fall of 237 feet/mile in the south versus 132 feet/mile in the north. Resulting lag time from occurrence of heavy rainfall to the peak rate of runoff, is, therefore, much shorter along the southern coastal plain.

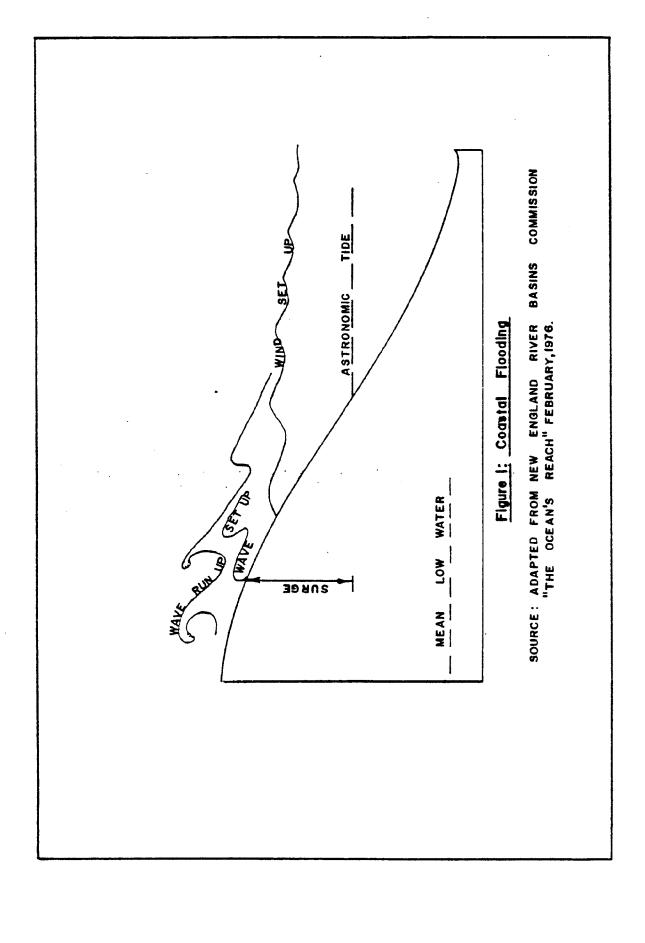
STORM SURGE

In addition to causing flash flooding in the coastal plain, the wind and waves generated by hurricanes and other storms can also cause damages to the coastline and near shore areas. These damages have three components: damage from storm surge, damage from storm swash or wave run-up, and damage from wind.

Storm surge is the storm-generated rise of water above mean sea level; its components are the astronomical tide, wind set-up or the piling up effect of storm winds on waves, and wave set-up, or the effect of offshore topography on wave height (see Figure 1). The height of the storm surge at any particular point will reflect both meteorological factors -- wind speed, storm trajectory, storm speed, barometric pressure -- and topographic factors -- offshore topography, shoreline configuration.

Tide frequency studies, performed by the National Weather Service for the Federal Insurance Administration, show that a storm-induced tide which occurs on the average once every 100 years (100-year storm) reaches heights ranging from 5.3 feet on the southwest coast to 8.8 feet on the southeast coast, and averaging 5.3 feet on the north coast. The steepness of the offshore topography limits the tides, which are highest in shallow waters. However, this same topography has the opposite effect on wave height (see below).

Francis P. Ho, Storm Tide Frequency Analysis for the Coast of Puerto Rico, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Hydrology, NOAA Technical Memorandum NWS Hydro-23, May 1975.



Much beach erosion and structure damage on the shore is caused by wave action rather than simply by the heightened storm tides. Wave action is a particularly serious problem in Puerto Rico because of the offshore and onshore topography. Steep offshore topography increases the height of the waves, which are limited in height to 0.7 of water depth. Because much of the coastline is steep, with relatively narrow coastal floodplains, in many places the entire flooded area is subject to wave action. In addition, the long fetch of open water allows storms to generate large waves.

Puerto Rico's north coast is exposed to damaging waves from hurricanes and tropical storms and from storms that originate in more northern latitudes. While tropical cyclones have stronger winds than the northern storms, both their fetch and duration are less, and as a result, the waves are roughly comparable in magnitude. The south coast is only subject to wave action from hurricanes and tropical cyclones.

A study of storm waves from northern latitude storms during the 1960's on Puerto Rico's north coast gives stage-frequency relationships showing a variation from 2.7 to 6.7 feet in the height of waves appearing on the average once every ten years. The height varies with the onshore topography; where flat land or low slopes are present, waves will dissipate their energy travelling inland and will not reach the heights that occur where steeply sloping onshore topography is present.

Large waves caused by three major storms between 1962-1968 caused extensive destruction of oceanfront structures, erosion and movement of beach sand, and disruption of coastal vehicular traffic. The highest wave elevations occurred on December 4, 1967, when more than 300 homes were destroyed and nearly 1,000 people were left homeless in the San Juan area and in Arecibo. Damage was most severe in the La Perla area, and portions of roads along the north coast between Camuy and Loíza Aldea were blocked by sand and water. Wave heights slowly receded until they reached normal elevations on December 10th.

Fred K. Fields and Donald G. Jordon, Storm-Wave Swash Along the North Coast of Puerto Rico, U.S. Geological Survey, Hydrologic Investigations Atlas HA-430, 1972.

Finally, potentially devastating waves, called seismic sea waves or tsunamis, may occur as a result of underwater earthquakes or landslides. Such a sea wave struck Puerto Rico in October of 1918, reportedly drowning eight people and destroying small houses near Point Agujereada. This tsunami was highest near Puerto Rico's northwest corner, decreasing in height as it passed along the coast towards the south and the east.

FLOOD-RELATED EROSION

In coastal areas, erosion is frequently part of a natural cycle of onshore-offshore migration of sand. An annual cycle is present that produces a "winter beach" and a "summer beach". During storms, beach material may be removed from the berm by storm waves but it normally returns
during calm weather. However, extreme wave conditions may carry the sand
to depths so great that normal waves cannot reach it, and the material is
lost to the beach system. (See Figure 2.)

Man's activity may increase the likelihood of flood-related erosion. For example, in areas where mangroves have been cleared, flood-caused erosion may be extensive. Where protective dunes have been excavated, erosion of areas behind the dunes may be caused by storm waves overtopping the dunes. Construction activities near the shore and sand extraction from beaches and river mouths may also make these areas more vulnerable to erosion from flooding.

Flood-related erosion occurs in riverine as well as coastal areas. The high velocity of flood flows is responsible for much of the damage caused by riverine flooding. Erosion and undermining of structures close to the stream banks are also major problems. Substantial damages to bridges and roadways are often directly caused by flood-related erosion.

Erosion caused by flooding is generally not treated separately from the flooding problem itself. Data on the incidence and costs of damages attributable to flood-related erosion are not generally available. However, the Department of Transportation and Public Works estimated that Tropical Storm Eloise caused damages attributable to flood-related erosion of approximately \$750,000.

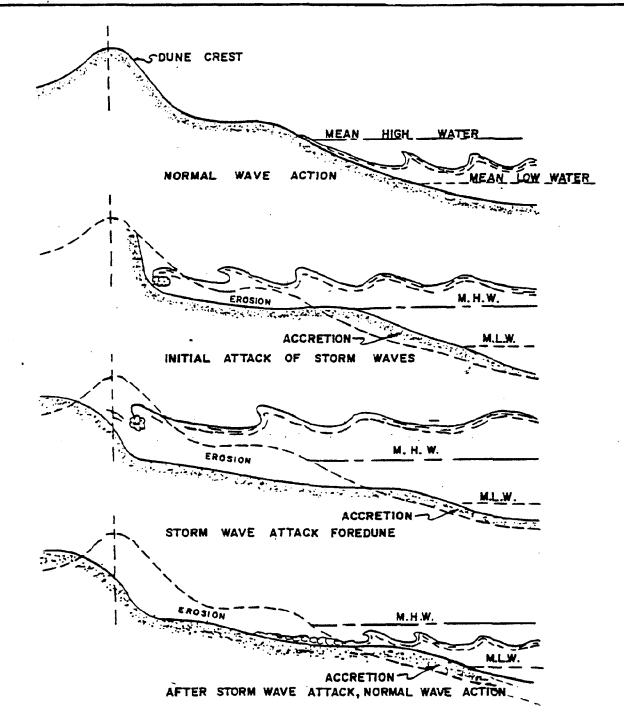


Figure 2: Schematic Diagram of Storm Wave Attack on Beach and Dune

SOURCE: ADAPTED FROM CORPS OF ENGINEERS, "SHORE PROTECTION MANUAL VOL.II"
COASTAL ENGINEERING RESEARCH CENTER, 1975, FIGURE 5.5

Historical Flooding

MAJOR HISTORICAL FLOODS 1

The most damaging floods in Puerto Rico's history have resulted from hurricanes that passed over or near the Island. Approximately 1,100 hurricanes have occurred in the Caribbean since the European discovery of Puerto Rico. Only about 140 of them have affected Puerto Rico, but they have caused more than 5,000 deaths and hundreds of millions of dollars in property damage.

Following is a list of major hurricanes which have affected Puerto Rico since 1871, with summaries noting storm paths and maximum wind speeds. 1 Figure 3 shows the paths of all hurricanes that have actually hit Puerto Rico since 1871. Many others have greatly affected the Island even though they only passed close by.

San Felipe - September 13, 1876

This storm entered Puerto Rico between Humacao and Yabucoa and exited between Rincón and Mayaguez. Forty-five ships were lost during this extremely destructive hurricane.

San Magin - August 19, 1891

The center of this storm approached Puerto Rico from the southeast, hit the Island on August 19, and exited by the north coast later that evening. The storm was of small diameter but of great intensity.

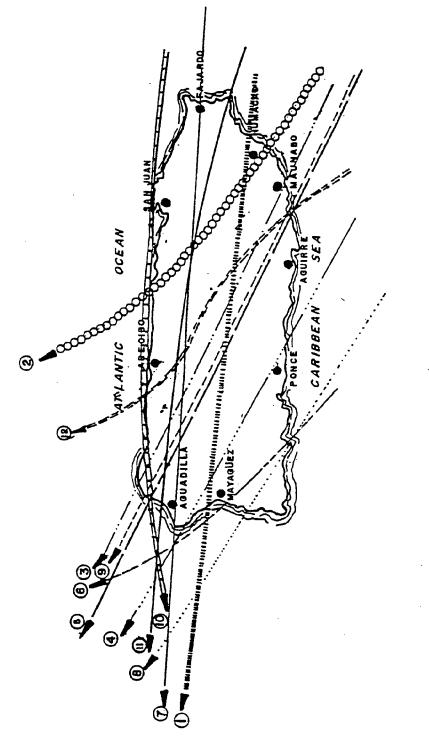
San Roque - August 19, 1893

This tropical storm, first detected on August 13, entered the southeast coast of Puerto Rico near Punta Guayanés and exited the Island near Isabela.

San Ciriaco - August 8, 1899

The storm center entered near Arroyo on the southeast coast at about 8 a.m. and left the Island near Aguadilla on the west coast approximately 6 hours later. The hurricane, one of the most destructive in Puerto Rico's history, took 3,000 lives and caused tremendous property damage. The maximum wind speed was estimated at about 104 mph.

Derived from: Francis P. Ho, Storm Tide Frequency Analysis for the Coast of Puerto Rico, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Hydrology, NOAA Technical Memorandum NWS Hydro-23, May 1975.



(7) SAN HIPOLITO -	B SAN NICOMEDES II	(B) SAN FELIPE II -	(O SAN NICOLAS	(1) SAN CIPRIAN	(2) SANTA CLARA (BE)
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O SAN	(2) SAN	3 SAN	Ø SAN	NÝS ∰	₩\$ @

22, 1916	1926	1928	1931	1932	1956
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SAN HIPOLITO AUGUST	(B) SAN NICOMEDES IL BEPTEMBER	SAN	"SAN NICOLAS	(1) SAN CIPRIANSEPTEMBER	SANTA CLARA (BETSY) AUGUST
O	W	. 😊	-	9	

Figure 3: Landfalling Hurricane For The Period 1871-1979.

SOURCE: NOAA, Office of Hydrology. "Storm Tide Frequecy Analysis for the Coast of Puerto Rico" Francis P. HO, May 1975.

San Hipólito - August 22, 1916

This storm, moving from the southern to western coast of Puerto Rico, caused an estimated 1 million dollars worth of damage. Maximum wind speeds, measured in San Juan, were 92 mph.

San Felipe II - September 13, 1928

Moving at an average speed of about 13 mph, this hurricane entered Puerto Rico along the southeast coast near Guayama and exited along the north shore between Aguadilla and Isabela. Wind speeds reached a maximum of 150 mph.

San Nicolas - September 10, 1931

Maximum wind speeds were recorded at 92 mph as this hurricance moved westward along the entire north coast of Puerto Rico. Damage caused by the storm was confined to a strip five or six miles wide extending from San Juan to Aguadilla.

San Ciprián - September 26, 1932

Property damage in excess of 30 million dollars resulted from this hurricane, which entered Puerto Rico near Ceiba on the eastern shore. As the center of the hurricane passed to the south, maximum winds of more than 115 mph were recorded.

Betsy (Santa Clara) - August 12, 1956

Hurricane Betsy travelled along a west-northwestward route from the southern coast of Puerto Rico near Guayama to the northern coast at Arecibo, at an average speed of 21-22 mph. Maximum wind speeds reached 115 mph.

Three of the most devasting hurricanes in Puerto Rico's history -- San Ciriaco, 1899; San Felipe, 1928; San Ciprián, 1932 -- are described in more detail below. 1

San Ciriaco - San Ciriaco, the violent hurricane which hit Puerto Rico on August 8, 1899, entered over land at Arroyo in the southeast in the early morning and left the Island that same afternoon at Aguadilla in the northwest. San Ciriaco, moving at a speed of 12 miles per hour (and reaching a maximum wind velocity of 104 miles per hour) whipped Puerto Rico for eight consecutive hours before it passed on to the Bahamas. A record 24-

¹ Derived from:

Louis A. Salivia, Historia de los Huracanes y Temporales de las Antillas, 1972.

Francis P. Ho, Storm Tide Frequency Analysis for the Coast of Puerto Rico, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Hydrology, NOAA Technical Memorandum NWS Hydro-23, May 1975.

Selected newspaper accounts.

hour rainfall -- 23 inches -- was registered in Adjuntas.

The National Weather Service had been restablished in Puerto Rico when San Ciriaco struck the Island and provided some advance warning of the storm. The public was also aware of the hurricane through the press, and appropriate flags and lights on ship masts were displayed as hurricane warnings. Still, the number of deaths from San Ciriaco was higher than from all previous hurricanes combined: over 3000 persons died as a result of the storm, mostly by drowning.

According to statistics which appeared in "La Gaceta de Puerto Rico" on January 20, 1900, San Ciriaco produced the following damages:

Total losses	-	\$35,889,013
Cyclone victims	-	890 persons
Flood victims	-	1294 persons
Total deaths	-	2184 persons
Wounded by hurricane	-	2569 persons
Wounded by floods	- · ,	195 persons
Total wounded	-	2764 persons

Agricultural damages were extensive. The coffee harvest for that year, valued at \$7,000,000, was completely destroyed and many coffee farmers abandoned their businesses. Most plantains and banana plants (the staple food of the rural population) were destroyed by wind or uprooted by water currents.

Both coastal and riverine flooding occurred. A tide levelled all buildings near the Port of Humacao. In Arecibo, 500 to 1000 persons were drowned from flooding of the Río Grande de Arecibo (part of the town remained under several meters of water for some time), and the lower valley of Ponce was covered by a convergency of flood waters from several rivers and streams.

¹Subsequently increased to 3,369.

Rainfall continued for several days after the hurricane, creating violent river flooding and more damages. For example, the day the hurricane was over, residents living along the main river bed in Ponce were ordered to evacuate to higher phaces. Some refused to leave and others returned in the afternoon with their possessions. A new and more violent river flood occurred that day, causing additional loss of life and property. There were similar occurrences at other places on the Island.

After the hurricane, a "Junta de Beneficiencia" was established by General Order #115, signed by Governor Davis, by which the Island was divided, for inspection, into 12 districts. Each district was assigned to a post commander who was to determine the effects of the hurricane, organize town cleanups and distribute food and other necessities to flood victims. Collection of municipal and insular taxes was temporarily suspended.

San Felipe - A second major hurricane that passed over Puerto Rico was San Felipe II. It followed a route similar to San Ciriaco, crossing the Island diagonally in 8 hours, 1 starting from the southeast and leaving by the northwest on September 13, 1928.

San Felipe II is considered the most violent and most disastrous hurricane to have affected Puerto Rico. The lowest barometric pressure (27.50 inches), the highest wind velocity (200 miles/hour), and the highest economic losses (\$50-\$85 million) were registered by this hurricane. The rainfall between September 13-14 was the highest recorded in 30 years. Even so, only partial records of the rainfall and wind velocity were made because the rain gauges and anemometers were damaged during the hurricane.

Three hundred persons were killed and thousands injured from San Felipe. However, deaths were considerably less in San Felipe than in San Ciriaco — in part due to a greater awareness of the coming hurricane through radio broadcasts (station WKAQ had been in operation since 1922). Two days before the storm, the U.S. Naval Station in San Juan started broadcasting every two hours to keep the public informed about the approximate

Hurricane winds lasted for approximately 12 hours according to local news reports.

route of the hurricane. The 75 police districts, into which the Island was divided at that time, were telegraphed about the nearby hurricane, and seaports around the Island were given similar warnings.

Property damages were enormous: around 770 school buildings were destroyed or damaged; sugar mills were reduced to rubble; and over 20,000 rural homes were completely destroyed, while close to 200,000 were partly damaged — leaving 83,679 families homeless. Telegraph and telephone systems were damaged, and transportation was impaired due to fallen trees, collapsed bridges, and landslides.

Agriculture, the mainstay of Puerto Rico's economy at that time, sustained considerable damages. One-third of the sugarcane harvest was lost; half of the coffee plants (and over half of the shade plants for coffee -- bananas, plantains, citrus trees, etc.) were destroyed. Tobacco plantations also suffered severe damage. In response to this devastation, a petition for 5 million dollars for agricultural rehabilitation was submitted to the federal government in Washington. An additional 10 million was requested specifically for rehabilitation of the two cash crops -- coffee and tobacco.

This was the first hurricane in which the American Red Cross provided assistance in Puerto Rico.

San Ciprián - San Ciprián, although lasting just a little over two hours, measures with San Felipe as one of the most devastating hurricanes in Puerto Rico's history. The storm, traversing the area from Fajardo to Isabela, struck on September 26, 1932, shortly before midnight.

The northeastern part of Puerto Rico was hardest hit, causing heavy losses in agriculture — the sugarcane and coconut groves of Loiza and Piñones were completely ravaged. Many wooden houses with corrugated zinc roofs were levelled by the effects of high speed winds in the area. One news report stated "Loiza Aldea has disappeared almost completely". In other parts of the Island, pineapple, sugarcane, and coffee crops were severely damaged, with 95 percent of the grapefruit and coconut crops lost.

Source - El Mundo (newspaper)

Over 46 municipalities were affected, 300 people were killed, over 40,000 buildings were destroyed, and 70,000 families were left homeless. In response to some 30-50 million dollars worth of property loss, both the Insular Government and the Reconstruction Finance Corporation allocated funds for rehabilitation and emergency assistance.

MAJOR RECENT FLOODS

Floods of October 1970¹ - Heavy rains in October 1970 caused extensive flooding in the eastern two-thirds of Puerto Rico (See Figure 4). Damages were estimated at \$68 million and 18 deaths were reported. The storm, caused by a tropical depression that stagnated south of Santo Domingo, lasted for six days and resulted in 60 municipios being declared disaster areas by the President.

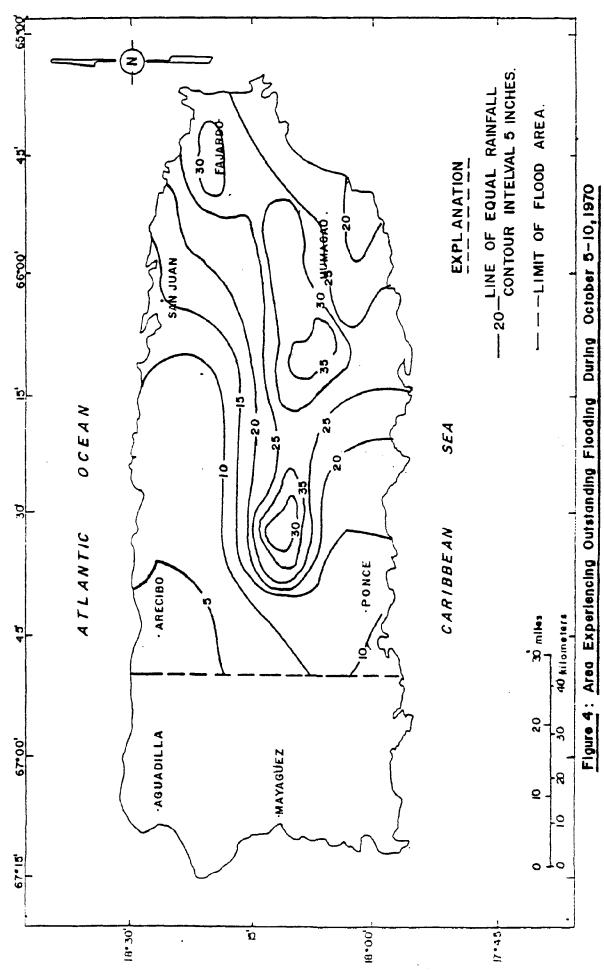
Precipitation information prior to 1899 indicates that the amount of rain during the October 1970 storm was the greatest in over 100 years. More than 38 inches of rain fell on some portions of the Island, and many locations reported the highest 6-day total rainfall since record keeping began in 1899. Total rainfall from the storm at some stations was as follows:

Ponce	10.61 inches	Cayey	32.77 inches
Cerro Maravilla	31.66 "	Yabucoa	22.92 "
Jayuya	38.42 "	Pico del Este	30.68 "
Aceituna	36.81 "	Río Piedras	15.20 "
Aguirre	27.24 "	Barceloneta	5.13 "

Hydrologically, the floods were unique for the streams in Puerto Rico. Usually, flood flows are single peaks that rise and fall within a 24-hour period. In the 1970 flood, however, streams throughout most of the Island were at flood stages for as long as 6 days. As many as nine peaks were recorded at some stream-gauging stations.

The rain started on Sunday, October 4th, and by Monday rivers began to flood. By Tuesday, many of the major rivers overflowed in at least 29 municipios. Although floodwaters receded somewhat in mid-week, rainfall increased again and by Friday, the fifth day of the storm, all rivers

Information derived primarily from: USGS, Floods of October 5-10, 1970
in Puerto Rico (William J. Haire), 1972.



SOURCE: USGS, FLOOD IN PUERTO RICO, MAGNITUDE AND FREQUENCY, WATER RESOURCES INVESTIGATION 78-141 JUNE 1979.

east of Santa Isabel on the southern coast and east of Arecibo on the northern coast were overflowing. Severe landslides also occurred in several places.

As noted above, damages from the flood were estimated at more than \$65 million. A USGS report summarized Department of Commerce information on damages as follows:

- emergency assistance was provided for over 10,000 people
- 600 houses were destroyed; several hundred more were damaged
- agricultural losses were estimated at \$8 million
- \$12 million in damages to roads and bridges occurred (6 bridges were destroyed and many others damaged).

The report also noted that damages were caused by debris and silt deposited by the flood waters.

The Department of Social Services, the Education Department, and the Health Department worked jointly to set up shelters throughout the Island for over 6,000 refugees.

The Presidential disaster declaration allowed the Federal Disaster Assistance Administration (FDAA) to provide disaster assistance. Disaster assistance funds provided by FDAA totaled \$14,573,861, almost all of which was for repairs and restorations to public facilities.

Following the floods of 1970 was the first time that Puerto Rico participated in the Federal Highway Administration's emergency relief program.

Floods of September 1975 - The floods which occurred in mid-September 1975 were caused by heavy rains which began as part of a tropical depression that increased in intentisy to Tropical Storm Eloise and then Hurricane Eloise. The storm was still classified as a tropical depression when it passed to the north of Puerto Rico, and did not reach hurricane intensity until it was about 35 miles north of the Dominican Republic. As a result, hurricane force winds did not affect Puerto Rico.

Economic Study of Puerto Rico. U.S. Department of Commerce, December 1979, Volume II, p. 412.

The primary effects of Eloise in Puerto Rico were due to flash floods and river floods which reached a peak on September 16th. The first heavy rain squall moved across eastern Puerto Rico early on September 15th, and during that day, heavy rains fell over the east and southeast sections of the Island. By late afternoon on the 15th, some of the main rivers were rising, with Rio La Plata about 12 miles west of San Juan nearly bank-full. Flood warnings were issued in the morning and repeated throughout the day predicting widespread, heavy, and damaging flooding. Major flooding occurred on 19 rivers on September 16th. There were severe flash floods on small streams, especially in western Puerto Rico, and numerous rock falls and landslides. (See Figure 5)

Total rainfall for the period from September 15th to 17th at selected locations was as follows:

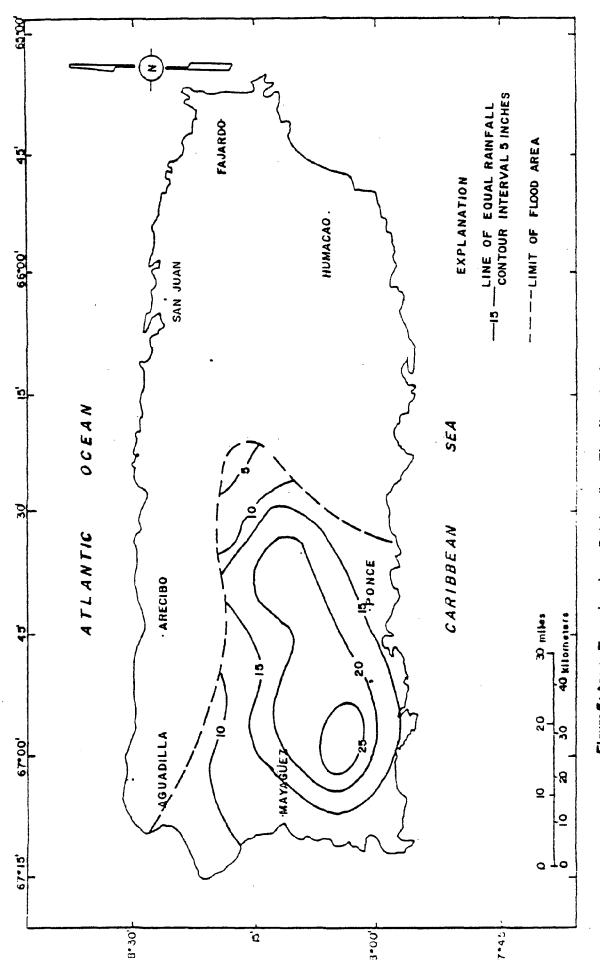
Arecibo	9.24 i	.nches	Sabana Grande	26.70 ir	nches
Barceloneta	4.75	11	Cerro Maravilla	18.83	11
Río Piedras	6.40	11	Jayuya	20.41	II
Yabucoa.	12.68	14	Maricao	22.47	11
Cayey	10.02	11	Utuado	8.61	11

Early warnings and the relatively lighter rains on Monday gave the Offfice of Civil Defense ample time to mobilize for the emergency. Even so, there were 34 deaths (with 29 additional people unaccounted for) and over 10,000 refugees. Property damages exceeded \$125 million, including 15 bridges destroyed and 39 damaged.

The entire Island was declared a disaster area. Disaster assistance from federal agencies included:

Federal Disaster Assistance Administration	\$58,369,000
Small Business Administration and Farmers	25,852,000
Home Administration Loans	₩Z
Federal Highway Administration	9,000,000

Puerto Rico Highway Authority, "Path of Tropical Depression - Storm-Hurricane Eloise", Report on the Damage Caused to Highways and Bridges, Federal Aid System, October 1975.



SOURCE: USGS, FLOOD IN PUERTO .RICO, MAGNITUDE AND FREQUENCY, WATER RESOURCES INVESTIGATION .78-141 JUNE 1979 Figure 5: Area Experiencing Outstanding Flooding During September 15-17, 1975

Department of Health, Education and Welfare	\$ 1,793,000
Agricultural Stabilization and Conservation Service	1,115,000
Total	\$96,129,000

Floods of September 1979 - (See Supplement)

Other Major Recent Floods - In addition to these Presidentially-declared flood disasters, Puerto Rico has experienced frequent floods that caused major damages even though they did not qualify for disaster declaration. Some of these are listed and briefly described below to give an idea of the frequency and nature of this flooding 1:

September 1960 (Hurricane Donna)	107 persons dead and many others without shelter. The Eastern portion of the Island was most affected, especially Humacao.
August 1961	Three deaths and 2,400 refugees. Total damage of about \$5.8 million. The Guayama area and surrounding towns were most affected.
November 1961	Two deaths and about 1,500 refugees. The whole Island was affected, with damages of thousands of dollars.
July 1964	Large floods in the San Juan Metropolitan Area, especially in Garden Hills, caused thousands of dollars in damages.
May 1965	One death and several injured. Most affected were San Juan and Trujillo Alto where 400 families were isolated when a bridge was destroyed.
December 1965	Severe flooding left two dead and millions of dollars in damages. The central and northern parts of the Island were most affected. Almost all the tobacco harvest and young fruits were lost. Several principal highways were cut off by landslides.
July 1968	One death and damages of about \$1.5 million. The area most affected was Mayagüez where Río Yagüez flooded 85 houses and 23 businesses. It was estimated as the worst flood in that area in 50 years.
October 1968	Mayagüez again suffered flooding from the Río Yagüez, which caused losses of over 2 million dollars.

Source: Puerto Rico Office of Civil Defense and the National Weather Service.

November 1968

One death and thousands of dollars in damages.

Portions most affected were the north and west.

The Rio Culebrinas caused much destruction.

January 1969

Floods in the San Juan Metropolitan Area were

Floods in the San Juan Metropolitan Area were estimated as the worst in the capital in 70 years. Many families were evacuated to shelters.

May 1969 Seven deaths and several thousand dollars in losses. The Office of Civil Defense evacuated more than 2,000 families to shelters.

November 1969 Floods throughout the Island caused three deaths and millions of dollars in damages. Areas most affected were Coamo, Fajardo, Loíza and Río Grande. Six hundred persons had to be sheltered.

Floods throughout the Island caused by 10 days of rain. Many highways closed by landslides and damaged bridges. Most affected areas were Ponce, Adjuntas, Juana Díaz, Coamo, and Manatí.

One of the most severe floods in the metropolitan San Juan history. More than 900 families affected and millions of dollars in damages. Puerto Nuevo area suffered considerable losses from flooding of Rio Piedras and Rio Puerto Nuevo.

Heavy flooding in eastern Puerto Rico including Vega Baja, Dorado, Puerto Nuevo and other areas of Metropolitan San Juan.

Heavy rains and flooding struck the northern portions of Puerto Rico. Two people were drowned with a total of about 500 people evacuated in areas of Arecibo, Vega Baja, Vega Alta and Manatí.

Tropical Depression north of Puerto Rico caused heavy rains in eastern part of the Island. One death and two injuries. Humacao and Caguas heavily affected.

Heavy convective rainshowers south of Mayaguez caused flooding near route 380 and one person drowned.

Heavy thunderstorms in the Mayagüez area caused the Yagüez River to flood. Twenty-six persons were evacuated by Civil Defense and other minor flooding occurred along the north coast.

Heavy flooding in eastern Puerto Rico with 500 families evacuated to shelters. Two deaths. Heavy flooding in the metropolitan area of San Juan, as well as the towns of Vega Baja, Toa Baja, Toa Alta, Dorado, Canovanas and Loiza.

June 1970

May 1970

November 1970

December 1970

August 1971

September 1972

October 1972

April 1973

August 1973

Flash flooding occurred in eastern Puerto Rico centered in the towns of Cayey, Gurabo, Las Piedras, Patillas, Humacao, Ceiba and Juncos.

One person drowned. Numerous landslides in the interior caused damage to roads.

Flooding in the eastern section of Puerto Rico from the close passage of Hurricane "Cristina" which degenerated into a tropical wave near Puerto Rico. Heavy rains affected the towns of Humacao, Yabucoa, Gurabo, Canóvanas and Fajardo with some 200 families evacuated to shelters.

Heavy rains fell in the southern sections of Puerto Rico causing flooding in Arroyo, Guayama, Patillas, Ponce, Coamo and Lajas. One man slightly injured in landslide.

SMALLER FLOODS

September 1973

October 1973

Puerto Rico is also subject to frequent small floods. Recent examples include floods during February and May 1979. The northeastern portion of the Island was most affected by the February floods, primarily the San Juan Metropolitan Area, Canovanas, Río Grande, Toa Baja, Guaynabo and Trujillo Alto. The State Civil Defense Agency reported a total of 200 families affected in the metropolitan area alone. During the second and third weeks of May, heavy rains caused extensive highway flooding in the metropolitan San Juan area. The municipalities of Río Grande, Canovanas, Luquillo, Fajardo and Ceiba along the northeast coast also experienced flooding. During the third week, the western part of the Island felt the effects of the heavy rains, and several towns were without electricity due to flooding. The Red Cross provided shelter for 227 families throughout the Island and 500 persons reported damages or property losses.

Much of the smaller scale, frequent flooding that occurs in Puerto Rico is the result of only moderately heavy rainfall combined with insufficient drainage. In many urban areas adequate storm drainage systems have yet to be developed. In many more, totally or partially clogged storm drainage systems cause minor flooding from even moderate rainfall. Streams that have been channelized also frequently become clogged with silt and debris, causing the streams to back-up and overflow. In several rivers, such as Río Grande de Arecibo, Río La Plata, and Río Cibuco, aquatic vegetation is

so thick that it prevents proper drainage and causes flooding.

There are no organized data on the historical frequency of smaller floods in the various areas of Puerto Rico. However, based on general information, the following locations have been noted as suffering recurring flood problems from relatively minor or small scale meteorological events (local heavy showers, local severe thunderstorms, etc.) 1:

- 'Aguadilla Sector Parterre subject to frequent floods from heavy rains.
- 'Cabo Rojo PR-301 in Cabo Rojo comprising Barrios Corozo, Pitahaya, El Combate, Pole Ojea, and other localities located along PR-301 are frequently flooded.
- 'Caguas Increasing density and construction in the Caguas metropolitan area appears to have increased runoff potential and minor flood frequencies in Bairoa and several adjoining urbanizations in the Rio Caguitas basin.
- *Canovanas Low lying areas near the sugar Central and Barrio San Isidro have been used for construction of houses which flood with locally heavy rains over and near the Rio Canovanas basin.
- *Carolina PR-874 all along Fernandez Juncos Avenue in Carolina is frequently flooded during heavy rains.
- 'Ceiba Although cleaned out after Hurricane Eloise, Río Daguao still floods whenever local high intensity rains occur.
- 'Fajardo Communities near Fajardo Beach are frequently flooded.
- 'Guayama Sector Puente Jobos de Guayama around Melania Creek is frequently flooded.
- -Hormigueros Urbanización Buenaventura subject to floods during heavy rains.
- 'Manati-Barceloneta Increasing industrial development and associated local drainage have caused problems in the areas bordering Rio Manati.
- 'Naquabo Cambimbora Street in Naquabo Beach.
- 'San Juan Chardon Street in Hato Rey.

Based on information provided by the U.S. National Weather Service and the P.R. Department of Transportation and Public Works.

- San Juan The Río Piedras-Puerto Nuevo basin contains a high population density and much construction including the new De Diego and Las Américas Expressways. Usually several warehouses and homes are affected in the lower portion of Puerto Nuevo several times a year.
- Toa Alta and Toa Baja Recent construction in the Río La Plata floodplain has resulted in minor problems due to local flooding from several small tributaries of Río La Plata.
- · Vega Baja Low lying access roads and streets with poor drainage cause local ponding problems along Rio Cibuco.
- 'Yauco Barrio Palomas in Yauco, flooded when sustained rains occur.
- Yauco Urbanización Luchetti in Yauco is frequently flooded by Río Yauco.

Assessment of Coastal Flood Hazards

FLOOD HAZARDS

This brief look at the history of flooding in Puerto Rico reveals that severe flooding can result from:

- · landfalling hurricanes
- hurricanes that pass nearby but do not actually hit the Island, and
- · non-hurricane storms.

Almost every part of the coastal area is subject to flooding from either flash floods or from coastal surges, and many parts of the interior are also subject to flash floods.

In the past 108 years, Puerto Rico has suffered severe damage from land-falling hurricanes, on the average, once every 9 years. Since 1871, the longest period between landfalling hurricanes has been 24 years. Twenty-three years have elapsed since the last hurricane, Betsy (Santa Clara), crossed Puerto Rico in 1956. Although the occurrence of individual

hurricanes cannot be predicted, the historical record indicates that Puerto Rico is due to be hit again. 1

Flash flooding from both hurricanes and other storms can be predicted with limited precision. Puerto Rico's relatively small size and the many small drainage basins that divide the Island prevent geographically detailed predictions of the occurrence of flash flooding. As a result, the warning time available is usually a matter of only minutes or hours.

The prediction of storm surges affecting the near shore areas is also uncertain. The state of the art for storm surge prediction is less well developed than for flash floods, and only limited study of storm surges has been performed for Puerto Rico.

Because minor flooding is so frequent, residents of many areas appear to have accepted flooding as an unavoidable part of life. This attitude seems to also extend to more serious flooding, with many people not taking the threat of dangerous flooding very seriously. Consequently, special effort is required to encourage measures to reduce and avoid flood damages.

FLOOD DAMAGES

Over the past 100 years, the types of damages have changed somewhat, but the total damage potential remains high. Most notably, fewer deaths have resulted from recent major floods and fewer buildings have been destroyed in those floods. Improved warning systems have greatly contributed to the reduced loss of life and changes in construction materials and practices probably account for much of the reduced structural damage.

On the other hand, personal property damage has greatly increased as personal wealth has grown, and damages to infrastructure, particularly roads and bridges, have increased as development has spread.

Hurricane David and Tropical Storm Frederic occurred while this report was in draft states. A Supplement, included at the end of the report, describes damages from these storms.

PART II. RESPONSE TO THE FLOOD HAZARD

Introduction

In Puerto Rico, as elsewhere, flood hazard management has been dealth with in piecemeal fashion. Four different aspects of flood hazard management are usually addressed, but rarely are they coordinated. These are:

- control of development within the floodplain
- measures (usually through construction) to control flooding
- emergency response to flooding
- post-flood recovery.

Good flood hazard management requires coordination of these activities, since they are related responses to a single problem. Post-flood recovery, in particular, provides unique opportunities to take action that will avoid future flood damages. In addition, some potentially useful measures are little used, including floodproofing, public education, and the location of infrastructure to reduce floodplain development.

At present, no one agency, either at the federal or Commonwealth level, has a clear legislative responsibility to oversee the range of responses to flood hazard problems and to coordinate the activities of other agencies related to flood hazard management. At the federal level, the Water Resources Council is the agency with the broadest responsibility in flood hazard management, but it has no authority to act directly on flood problems. The Council merely sets policy, which is carried out by a multitude of agencies, and establishes planning guidance.

The greatest opportunity for coordinated floodplain management lies with the Government of Puerto Rico. In fact, the Water Resources Council has stated that "the Federal Government has a fundamental interest in how the Nation's riverine, coastal and other floodplains are managed, but the basic

The Process of Responding to Flood Hazards

Responding adequately to flood hazards requires an understanding of the extent and degree of the flood hazard, knowledge of the range of possible responses to the hazard, and then a choice of the most appropriate response or mix of responses.

DELINEATION OF HAZARD AREAS

It is essential to know which specific areas are subject to each hazard, including areas subject to more than one hazard (e.g., riverine flooding and storm surge). Two important aspects of hazard delineation are:

- determining the likelihood of the hazard occurring and how severe it will be, in order to estimate acceptable uses of the area
- mapping of the hazard areas.

Some problems which may affect the reliability and comparability of flood hazard maps are: inadequate or conflicting data or utilization of different methods for mapping floodable areas or for calculating the frequency of the event.

POSSIBLE RESPONSES TO FLOOD HAZARDS

One of the objectives of this study is to increase an awareness among government agencies of the range of choices available for adapting to recognized coastal flood hazards. These options can be organized around three management strategies:

- A strategy to reduce susceptibility to flood damage and disruption. Implementing tools include:

U. S. Water Resources Council, A Unified National Program for Flood Plain Management, p. III-1, July 1976.

- · development and redevelopment policies
- · floodplain regulations
- · floodproofing
- · information dissemination and public awareness
- flood forecasts and warnings
- tax adjustments
- A strategy to control flooding. Implementing tools include:
 - · construction of dams, dikes, levees and floodwalls
 - channel alterations
 - highflow diversions and spillways
 - · land treatment measures
 - · on-site detention systems
- A strategy to minimize the impact of flooding on individuals and the community. Implementing tools include:
 - flood insurance
 - tax adjustments
 - · flood emergency measures and post-flood recovery
 - · disaster preparedness and response plans
 - . post-flood recovery
 - · hazard mitigation

In choosing an appropriate response from these tools to deal with a flood hazard, more than one course of action is usually possible. Typically, there are many possible choices, or combinations of choices, for responding to the flood hazard — each with advantages and disadvantages, and each interacting in some way with other options. At least three types of interactions among responses to the flood hazard may be identified:

- the adoption of one response may encourage or hinder the adoption of others (e.g. the availability of flood insurance may encourage development in an area; structural measures may discourage land use regulation).
- the adoption of one response may affect the frequency or extent of the hazard at some future time (e.g. channelization of a stream may reduce the frequency and extent of future flooding).
- the adoption of one response may affect the frequency or extent of the hazard at another location (e.g. construction of a jetty may cause buildup of the beach on one side of the jetty, but accelerate erosion on the other side).

The impact of choosing one or a particular mix of options must be assessed, and in evaluating the impacts, the cost to the community and individuals must be considered, as well as the potential benefits. Environmental impacts must also be considered, and, where possible, options should be chosen which maintain maximum flexibility in order to avoid taking actions which could lead to irreversible changes with adverse social and environmental consequences.

AGENCY INVOLVEMENT IN FLOOD HAZARD MANAGEMENT

In Puerto Rico, as in many states, no single agency has the responsibility for managing floodplain management activities and ensuring that the activities of the many involved agencies are coordinated. Numerous agencies have varying levels of involvement in flood-related activities. (Emergency measures during floods, particularly, involve many agencies which are otherwise not directly involved in flood hazard management.) However, several key agencies can be identified:

Commonwealth Agencies

Planning Board:

- 'develops policies to guide overall development of the Island (including development in floodable areas) through its land use plans, the integral development plan, the 4-year investment plan, and the capital improvement program
- -develops regulations to control development -- including zoning, subdivision, and construction regulations, and a special regulation for floodable areas
- ·reviews and approves major project proposals
- *coordinates activities related to the National Flood Insurance Program
- 'serves as the clearinghouse for federally-funded projects

Regulations and Permits Administration:

- implements the planning regulations adopted by the Planning Board and exercises other authority delegated to it by the Planning Board
- ·issues construction and use permits
- 'evaluates detailed subdivision proposals (once the change of land use is approved by the Planning Board) and proposals for community facilities, including those in floodable areas

- .provides technical assistance for preparation of project plans
- responds to consumer complaints regarding illegal use or construction of buildings
- •monitors construction in floodable areas, in cooperation with the Department of Housing and the Department of Natural Resources, to prevent or remove illegal structures

Department of Transportation and Public Works:

- •responsible for the design, construction and maintenance of flood control works, as planned in cooperation with the Department of Natural Resources, including dikes, dams, ditches, levees, channels, floodwalls, detention reservoirs, and pumping stations
- ·evaluates all project proposals in floodable areas
- carries out field inspections of flood-control works to estimate damages and rehabilitation costs following flood emergencies
- reconstructs or rehabilitates public buildings damaged by floods

Department of Natural Resources:

- -determines priorities for flood control measures for each watershed based on cost estimates, hydraulic and hydrologic studies, land use conflicts, and cost-benefit analysis
- ·advises the Planning Board with regard to development of regulations for floodplain management and to delineation of flood zones for the purposes of Planning Regulation No. 13
- -maintains a computerized hydrologic data bank
- ·responsible for water resources planning and coordination
- •reviews project proposals in coastal areas as well as certain other proposals referred to the Department
- ·regulates sand extraction along river banks and beaches
- ·responsible for hazard mitigation planning

State Civil Defense Agency:

- maintains a comprehensive disaster preparedness plan (Emergency Operations and Disaster Control Plan), which details agencies' responsibilities in regard to emergencies and disasters
- coordinates the activities of all agencies during emergencies and disasters

Flood control responsibilities of the Department of Transportation and Public Works will be transferred to the Department of Natural Resources in 1980.

- -submits applications and requests for disaster assistance from Commonwealth agencies and municipalities to the Federal Disaster Assistance Administration
- ·reviews emergency plans prepared by other agencies 1

Aqueduct and Sewer Authority and Puerto Rico Electric Power Authority:

•responsible for control of flood gates on various dams to minimize the impct of flooding

Federal Agencies

Corps of Engineers:

- -prepares floodplain and special flood hazard information reports
 and flood insurance studies
- ·conducts flood control and beach erosion control studies
- •plans and constructs flood control and beach erosion control projects
- ·assists in emergency flood fighting
- •grants permits for construction and operations in wetlands and navigable waters

Federal Emergency Management Agency: 2

- makes grants for comprehensive disaster preparedness and assistance planning
- coordinates disaster services and assistance provided by other federal agencies (including unemployment compensation, food stamps, debris removal, etc.)
- •provides grants to individuals and families to repair, replace, or rebuild residences
- :provides grants to repair, rebuild or replace public facilities damaged or destroyed by a major disaster

Many federal and Commonwealth agencies become involved in disaster relief and assistance: for a summary of these activities, see Table 3, page 71.

In 1979, the emergency fuctions of several federal agencies, including the Federal Insurance Administration and the Federal Disaster Assistance Administration, were consolidated to form the Federal Emergency Management Agency (FEMA).

- •provides temporary housing to families and individuals displaced
 by a major disaster
- prepares detailed maps of flood hazard areas (through contracts with the Corps, USGS, and DNR and private contractors)

National Weather Service:

- •collects climatological data, prepares weather forecasts, and issues flood warnings
- 'maintains a continuous measurement system of recording rain gauge stations
- develops and installs flash flood alarm systems
- ·assists in organizing and training observers in flood warning systems and preparedness programs.

Geological Survey:

- collects data on water resources, including records of stream discharge, runoff, and sediment discharge from a network of gauging stations
- collects and interprets data on historic flood peaks, inundated areas, and magnitude, frequency, and duration of flood flows
- prepares topographic surveys and maps
- ·prepares flood-prone area maps and flood insurance studies

Soil Conservation Service:

- provides advisory services and technical assistance to the 17 local Soil Conservation Districts for resource conservation and development projects, including flood prevention and erosion control
- provides technical and financial assistance for improved utilization of land and water resources in small watersheds, including land treatment and channel improvements
- •conducts soil surveys
- ·assists in conducting river basin surveys and flood hazard studies
- •provides emergency restoration measures (e.g. channel restoration)

Water Resources Council:

•provides a forum for interagency and intergovernmental coordination
 of water resources planning activities, including planning studies,

development of principles and standards for project evaluation, and regional and national water supply assessments

- makes grants for water resources planning
- •provides guidelines for assisting federal agencies in complying with an executive order on floodplain management (E.O. 11988, May 1977)

Private Agencies

American Red Cross:

provides a range of assistance in cooperation with local agencies following flood disasters, including shelter, food, clothing, first aid, and counseling on longer term recovery needs

Response to the Flood Hazard

The following sections describe the management strategies and tools listed above that are available for responding to flood hazards. A brief, general description (in italics) of each tool that can be employed for the three management strategies is followed by a more detailed description of how -- and by which agencies — each of those tools is currently utilized in Puerto Rico.

MANAGEMENT STRATEGY 1: REDUCE SUSCEPTIBILITY TO FLOOD DAMAGE AND DISRUPTION

This strategy includes actions to avoid dangerous, uneconomic, undesirable, or unwise use of the floodplain. Implementation rests largely with the Government of Puerto Rico.

Development and Redevelopment Policies

Public actions can reduce susceptibility to flood damage and guide development away from floodplains.

Adapted from: U.S. Water Resources Council, A Unified National Program for Flood Plain Management. Washington, D.C. July 1976.

- Location of services and utilities can reduce flood loss potential by guiding private and public developments to nonflood or low risk areas. These services and utilities may also be designed to reduce flood damages.
- Open space acquisition lessens the potential for flood losses and their consequences. Land may be purchased directly, or control may be purchased through easements or development rights, for the purpose of precluding future uses incompatible with flood management programs.
- Land acquisition followed by permanent evacuation of developed areas (including the elimination of non-compatible uses and relocation of residential and other structures) may also be employed, but less frequently than other tools. In some instances, however, permanent evacuation of floodplain areas may be the only economically feasible alternative.
- Redevelopment and renewal offer opportunities for improving blighted floodplain areas. The motives for renewal are usually broader than just flood damage reduction, but the principles of floodplain management would still be employed.

Primary responsibility for the development and implementation of public policies and actions to guide development throughout Puerto Rico, including coastal flood hazard areas, rests with the Planning Board.

Official Planning Board policies on development in flood hazard areas are contained in the Objectives and Public Policies for Land Use, adopted by the Board in June 1977. Because these Planning Board policies apply throughout the Island, including the coastal zone, they were incorporated into the Puerto Rico Coastal Management Program by the Department of Natural Resources in July 1978. The principal objectives and public policies relating to flooding are quoted below:

OBJECTIVE

To reduce to a minimum the danger of loss of life and physical damage in the country, as a result of flooding and the action of wave surge -- at the same time identify and promote those land uses and activities compatible with these conditions.

l Official English translation.

PUBLIC POLICIES 1

- 10.00 To protect the population actually residing in floodable areas or in areas affected by the action of wave surge.
 - 10.01 To construct engineering works which will, at a reasonable cost, prevent property damage and risks to the lives of the citizenry actually affected, giving priority to these works above any other flood control measures.
 - 10.02 Where necessary, to take the appropriate measures to relocate these persons.
- 11.00 To prohibit land development and construction of structures for urban expansion and other activities which are expressly excluded by current regulation in areas affected by floods and wave surge, except when flood control works or protection against wave surge already exist, are under construction or can be provided at a reasonable cost, to protect the property and guarantee the safety of all the people affected in those lands which are not agricultural(ly) productive, do not have important natural resources, and are not environmentally critical.
- 12.00 To stimulate agricultural development in floodable areas which have such potential.
- 13.00 To construct flood control works with an agricultural approach in areas where it is appropriate, and which will result in an increase in agricultural production.

These official Planning Board policies are the most formal and broadest statement of the Commonwealth's position — but not the only expression of public policy — regarding development in flood hazard areas. Regulations, programs, and activities of the Planning Board and of other agencies are a less formal, but still integral, part of the total Commonwealth policy regarding development in flood hazard areas. These individual activities are discussed in following sections.

In addition to these specific statements on floodable areas, several of the objectives and policies relating to infrastructure and protection of natural resources indirectly affect development within flood hazard areas. For example, insofar as possible, floodable areas are not to be used for locating infrastructure.

Floodplain Regulations

In the floodplains that are not fully developed, floodplain regulations can be used to reduce susceptibility to future flood damage. Less often, they may also affect developed areas by controlling redevelopment. Regulations are frequently used in combination with other techniques to control development in floodplains, and a combination of regulatory tools is often necessary.

Regulation of flood hazard areas may be initiated through general legislation establishing floodplain regulatory programs which provide a basic framework of guidelines and provisions for implementation. Specific regulation of flood hazard areas is principally through zoning, subdivision regulations, building and housing codes, and sanitary codes with specific flood hazard provisions.

The Planning Board has primary responsibility for establishing specific floodplain regulations. Authority to develop floodplain regulations was given the Board by Law Number 3 of September 1961, as amended (Law for the Control of Building in Zones Susceptible to Flooding). The 1979 amendments to Law 3 require the Board to consult with DNR in developing its regulations for floodable areas.

Floodplain regulations (Planning Regulation Number 13) under Law Number 3, as amended, were first adopted by the Planning Board in January 1972. Passage of these regulations made it possible for Puerto Rico to become eligible for the Emergency Phase of the National Flood Insurance Program.

Adoption of these initial regulations in 1972 was an important first step in controlling development in floodplains, but they were recognized as not entirely sufficient. For example, the regulations did not cover flood-related erosion or the alteration of sand dunes and mangroves. Some ambiguities also existed in the regulations regarding the flood hazard zones specified and implementation and monitoring responsibilities.

The Planning Board revised Planning Regulation Number 13 in July 1978. Three flood zones are defined in the regulation (see Figure 6). The

¹The flood insurance program is discussed in more detail in a later section.

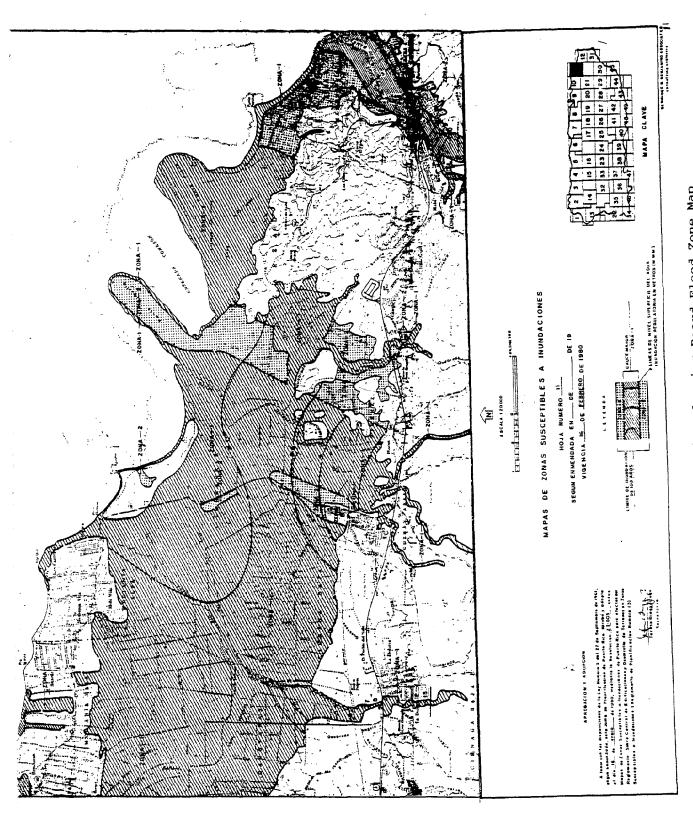


Figure 6: Example of a Planning Board Flood Zone Map

most important provisions of the revised Planning Regulation Number 13 are summarized below:

Zone 1 - Unfit for Building: Includes lands located within the regulatory floodway or provisional floodway, 1 lands subject to action of coastal surges, or those prone to erosion or mudslides due to flooding. No new building is permitted in this zone. Existing buildings cannot be enlarged, but repairs and floodproofing are allowed. Uses of existing buildings cannot be changed unless the new use will reduce the risk to loss of life and property. No new living units can be created. Land may not be subdivided. Landfill in Zone I is subject to severe restrictions, and no landfill is permitted in mangrove areas nor is any alteration of sand dunes along the coast permitted which might affect flooding from wave action. Open space use is permitted for certain types of agriculture and recreation, for uses incidental to industries, commercial establishments and residences, and/or authorized public utilities.

Zone 2 - Fit for Building Under Certain Conditions: Includes those lands located between the limits of the floodway or the provisional floodway and the limits of the floodplain. New building is permitted in Zone 2 if it is properly floodproofed, if the first floor is higher than the regulatory flood, and if obstruction to the flow of water is minimized. Prefabricated structures or mobile homes, in addition to being subject to the above restrictions, must be securely anchored to the ground. Enlargements and repairs can be made if the structure is properly floodproofed. However, if these changes equal or exceed 50 percent of the market value of the structure, the first floor of the structure must be elevated to the level of the regulatory flood. Few restrictions on use of Zone 2 apply as long as the above requirements are met. Land in Zone 2 may be subdivided if the land and structures are protected from flooding and coastal surges. Proposals for subdivision must be endorsed by the Department of Transportation and Public Works, and for projects in the coastal zone an endorsement by the Department of Natural Resources is required. Landfill is permitted subject to restrictions.

The floodway is defined as "The water course channel of a river, creek or brook and those adjacent lands determined necessary by a hydrological study to carry the flow of water during an extraordinary (100-year) flood of a river, creek or brook." Law 3 of 1961, as amended, provides that the Department of Natural Resources assist in the identification and delineation of floodable areas and floodways. Prior to completion of hydrologic-hydraulic studies to establish the floodway, the Planning Board may designate provisional floodways based on available data.

Zone E - Special: Includes areas located within the floodplain or subject to coastal surges, that are already occupied by a settlement or town. New buildings are permitted if they minimize obstruction to the flow of water, are properly floodproofed, and the elevation of the first floor is higher than the regulatory flood. Use of land in Zone E is similar to that of Zone 2. Land may be subdivided, and landfill is permitted.

Additional Provisions: Permits are required for the construction or alteration of any structure within Zone 2 and Zone E, in accordance with the specific restrictions applicable to each zone. (Since no alteration or construction is permitted in Zone 1, no permits may be issued for such activities in that zone.) Permits are issued by the Regulation and Permits Administration. The Planning Board, however, may intervene and provide direct authorization for a project. The Regulation and Permits Administration is also responsible for monitoring illegal construction in floodable zones or provisional floodable zones.

In addition to Planning Regulation Number 13, the Planning Board has adopted other regulations that directly affect development in floodable areas:

Planning Regulation Number 3 - Land Subdivision Regulation: Requires minimum standards for the construction of storm drainage and sanitary sewer lines in new subdivisions. (The Planning Board adopted standards for the design of storm sewers in June 1975.)

Planning Regulation Number 4 - Zoning Regulation: Includes zoning of floodable areas and areas subject to stormwash within low density R-O Zoning districts and declares that floodable areas be considered "Special Cases within District R-O". Since 1975, Planning Regulation Number 4 has also included a provision that all new buildings must be set back from the maritime zone a distance of 2.5 times their height.

Planning Board regulations apply to all public and private development in Puerto Rico except that occurring on federal property. Implementation of these Planning Regulations occurs through the review and approval (or disapproval) of development proposals. The Planning Board performs the initial review of all development proposals to determine if they require a change in land use or zoning. Construction plans are reviewed by the Regulation and Permits Administration (RPA). The RPA issues construction and use permits for those proposals that meet Planning Board and RPA regulations and operating procedures. The RPA conducts this review and approval

process at its central office in San Juan and at 6 regional and 3 subregional offices around the Island.

Numerous other agencies assist the Planning Board and the Regulation and Permits Administration by reviewing and commenting on development proposals. For example, projects proposed for location in floodable areas are evaluated by the Department of Transportation and Public Works, Flood Control Area, and in the coastal zone, by the Department of Natural Resources, among others. Their recommendations are submitted for the Planning Board's consideration.

Commonwealth agencies that initiate projects in floodable areas are responsible for insuring that they are in compliance with Planning Regulation Number 13 and any other applicable Planning Board regulations. Particularly important agencies in this regard are the Department of Housing, Economic Development Administration, Aqueduct and Sewer Authority, Department of Natural Resources, and Department of Transportation and Public Works. To the extent that these agencies recognize, understand, and adhere to the policies and regulations established by the Planning Board, the greater is the likelihood that development in the floodplain will actually be avoided, and the less burden is placed on the Planning Board and RPA.

Most of these agencies also have their own policies and operating procedures regarding development in floodplains. In addition, whenever these agencies carry out projects that receive financial or other assistance from the federal government, they must comply with the regulations, guidelines, and procedures established by the particular federal agency. In response to the President's Executive Order 11988 of May 24, 1978 on Floodplain Management, each of the federal agencies has recently revised its procedures to avoid, wherever possible, support of development in floodplains. For example, the Puerto Rico Aqueduct and Sewer Authority must construct sewerage facilities in compliance with EPA regulations and guidelines which seek to avoid running sewer lines through floodplains, if such a location may increase development pressures in the floodplain.

Floodplain regulations cannot be adequately implemented unless they are supported by complete and accurate floodplain maps. Planning Regulation Number 13 requires that maps be prepared for all areas subject to flooding, whether from river or from coastal surges. Detailed floodplain mapping has not yet been completed for all of Puerto Rico's floodplains. The following paragraphs describe the status of mapping conducted in support of Planning Regulation Number 13 and the National Flood Insurance Program.

Flood Insurance Rate Maps (FIRM's) - The Federal Insurance Administration has prepared initial Flood Insurance Rate Maps, based on available information, for each of Puerto Rico's major floodplains. These initial FIRM's became effective August 1, 1978, the date that Puerto Rico entered the Regular Phase of the National Flood Insurance Program. They classify floodable areas as subject to the 100-year flood (Zone A), or the 500-year flood (Zone B). Areas outside the 500-year flood boundary are classified as Zone C.

Preparation of more detailed FIRM's is now underway based on detailed Flood Insurance Studies being conducted in each of 32 basins which FIA is using for mapping purposes (see Figure 7). The Flood Insurance Rate Maps (FIRM's) that FIA prepares are official maps that delineate both the area in which flood insurance may be sold under the Regular Flood Insurance Program, and the actuarial rate zones applicable in the area. The flood insurance maps display the zone designations according to areas of designated flood hazards (see Figure 8). The zone designations used in the FIRM maps are:

- A within 100-year floodplain, but 100-year flood elevations not determined.
- AO zone of 100-year shallow flooding -- 1 to 3 feet; product of flood depth (ft.) x velocity (ft./sec.) less than 15. 100-year flood elevations not determined.
- Al-A30 detailed risk zones in 100-year floodplain. 100-year flood elevations and flood hazard factors determined.

On April 2, 1979, FIA became part of the new Federal Emergency Management Agency (FEMA).

²FIA contracted with the U.S. Geological Survey, the Corps of Engineers, and the Puerto Rico Department of Natural Resources to prepare the maps.

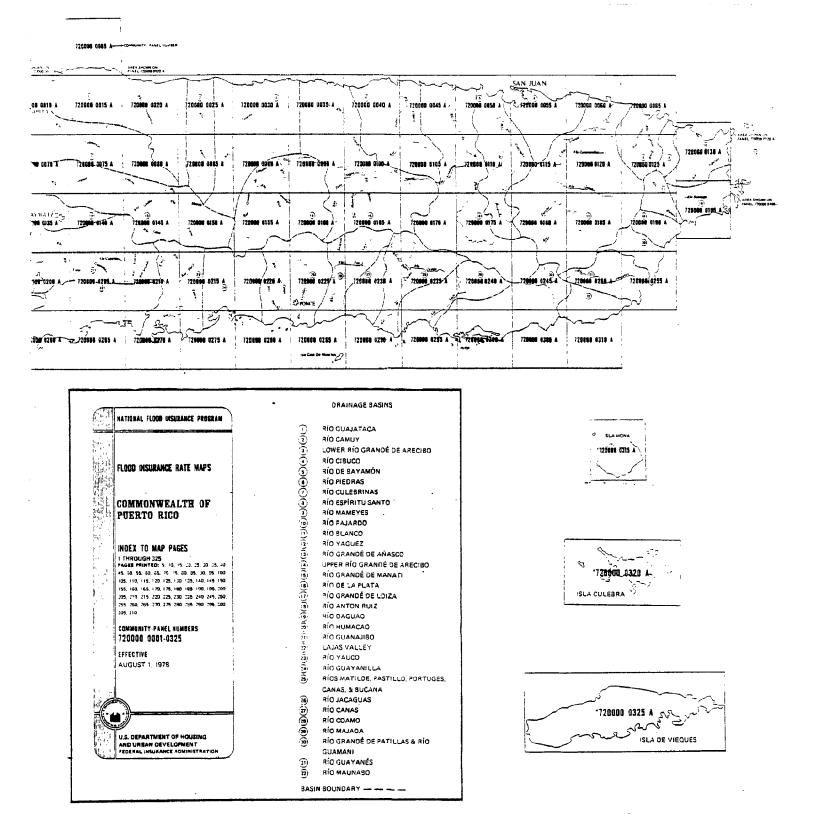


Figure 7: River Basins and Map Panels Used For The National Flood Insurance Program

ELEVATION REFERENCE MARKS

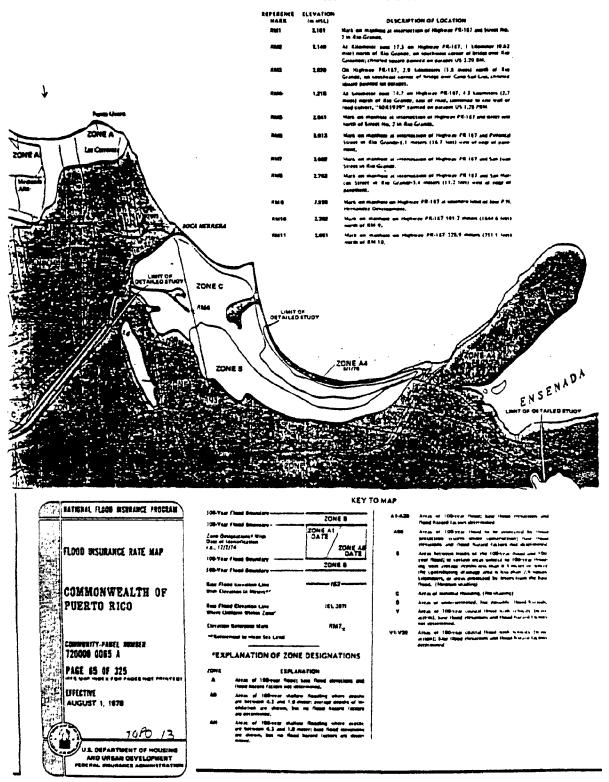


Figure 8: Example of a Flood Insurance Rate Map (FIRM)

- B area between limits of 100-year flood and 500year flood; areas of 100-year shallow flooding with depths less than 1 foot.
- C areas beyond 500-year flood.
- D extent of undetermined, but possible, flood hazards.
- V zone of 100-year coastal flood with wave action; base flood elevations and flood hazard factors not determined.
- vo zone of 100-year shallow coastal flooding with wave action; flood depth 1 to 3 feet; product of depth (ft.) x velocity (ft./sec.) more than 15.
- V1-V30 detailed risk zones of 100-year coastal flood with wave action; base flood elevations and flood hazard factors determined.

Mapping of the detailed FIRM's has now been completed in 11 of the 32 basins, and should be completed in 18 of the remaining basins during 1980.

Provisional Flood Zone Maps - As a temporary means of enforcing Planning Regulation Number 13, the Planning Board prepared and adopted Provisional Flood Zone Maps based on the Flood Insurance Rate Maps prepared by FIA. These maps designate all of Zones A and V on the FIRM's as provisional floodways. Planning Board policies permitted development within these provisional floodway if the sponsor of the proposed development conducted appropriate hydrological studies to determine a floodway and the proposed development met the requirements of Planning Regulation Number 13. These maps were replaced on February 16, 1980 by Provisional Floodway Maps.

Provisional Floodway Maps - On February 16, 1980, the Planning Board adopted a new set of maps to aid in implementing Planning Regulation Number 13. These maps identify provisional floodways (Zone 1), areas of the 100-year floodplain outside the provisional floodway (Zone 2), and developed areas within the 100-year floodplain (Zone E).

Flood Boundary and Floodway Maps - As FIA (through its contractors) conducts detailed Flood Insurance Studies and prepares detailed FIRM's, it also works with Puerto Rico to determine the Regulatory Floodway. As these studies are completed, FIA will prepare a second set of maps called Flood Boundary and Floodway Maps that delineate the Regulatory Floodway. These will replace the Provisional Floodway Maps.

Floodproofing

Floodproofing consists of modifications to structures, their sites, and building contents to keep water out or reduce effects of water entry. It allows development in lower risk floodplain areas by keeping damage within acceptable limits. However, if used inappropriately, floodproofing can increase unwise use of floodplains.

Planning Regulation Number 13 requires that new construction and reconstruction within each of the three floodable zones be performed so that the structures will safely resist the effects of flooding or the actions of coastal waves. Such construction measures are considered "floodproofing" of the structures. Many different techniques are available to aid in floodproofing properties, from elevating the structure on fill to simply removing from the lower levels of a structure anything that can be damaged by a flood.

In Puerto Rico one of the most common floodproofing techniques in use is the elevation of the structure on a raised foundation. Frequently this takes the form of providing a carport and open space underneath the structure. Another frequently used technique is the use of earthfill to raise the entire structure above the general level of the floodplain. (Floodproofing on the mainland most commonly applies to basements, which are seldom found in Puerto Rico.)

Although Planning Regulation Number 13 states that any construction or reconstruction in floodable areas requires acceptable flood-proofing and must conform to applicable building codes, no codes are specifically mentioned and no mention is made of what kinds of floodproofing techniques are acceptable. Planning Regulation Number 7, Building Regulation, does not provide specific information on floodproofing.

Although Planning Board regulations do not provide guidance on acceptable floodproofing techniques, each agency that carries out construction activities may have its own building codes or guidelines that supplement Planning Board regulations and sometimes address

floodproofing. As an example, the Department of Transportation and Public Works has recently published (1979) a <u>Manual on Highway Design in Puerto Rico</u> which includes sections on floodplain encroachments.

Information Dissemination and Public Awareness

Flood hazard information is necessary for sound floodplain management. The public (including government agencies) must be aware of the dangers of flooding; specifically, which areas are subject to flooding, what the chance is of a flood of a particular magnitude occurring, and how much damage can be expected from flooding. Without this information, neither the general public nor government agencies can make informed decisions and take appropriate actions to protect themselves or their clients from potential flood losses.

Data collection and dissemination. Two agencies -- the U.S. Geological Survey and the National Weather Service -- currently collect most of the basic data needed to determine the location, frequency and magnitude of flood hazards -- information essential to other agencies as a basis for developing and implementing policies, regulations, and other programs on floodable areas development. The U.S. Geological Survey collects streamflow data, including records of stream discharge, runoff and sediment discharge. The National Weather Service collects climatic data, including records of rainfall and wind patterns.

Other agencies also maintain records or develop data that is useful in determining flood hazards: The Aqueduct and Sewer Authority and the Puerto Rico Electric Power Authority collect data on streamflow into and discharges from reservoirs under their control; the U.S. Soil Conservation Service prepares soil survey maps that aid in determining areas subject to flooding; the Department of Natural Resources maintains a computerized data bank of hydrologic information; the Corps of Engineers has prepared nine floodplain information reports and seven special flood hazard information reports (see Table 1); and the Geological Survey analyzes historic flood data and prepares hydrologic atlases showing the extent of past floods (see Figure 9).

Table 1: Corps of Engineers Flood Plain and Special Flood Hazard Information Reports

FLOOD PLAIN INFORMATION STUDIES

Flood plain information studies have been completed for the areas listed below:

	Completion
Title	Date
Río de Bayamón, P.R.	1965
Rio Caguitas, P.R.	1969
Rio Cibuco and Rio Indio, P.R.	1973
Río Guayanilla, P.R.	1967
Rio Humacao, P.R.	1966
Rio La Plata, P.R.	1965
Rio Manati, P.R.	1967
Río Matilde, P.R.	1977
Rio Maunabo, P.R.	1970

EXPANDED FLOOD PLAIN INFORMATION STUDIES

An Expanded Flood Plain Information Study is underway for the area listed below:

Title

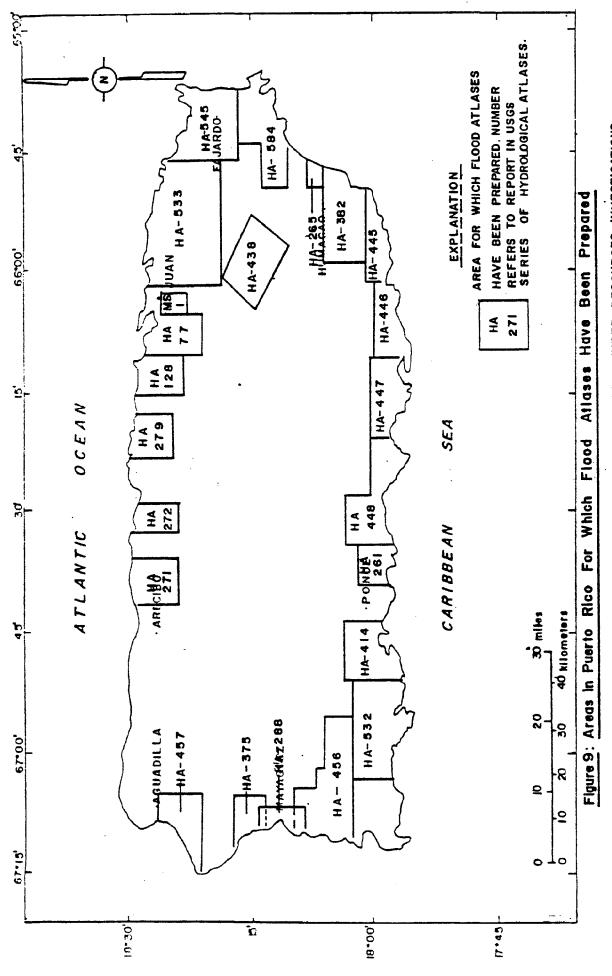
Río Tallaboa Basin, P.R.

SPECIAL FLOOD HAZARD INFORMATION STUDIES

Special flood hazard information studies have been completed for the areas listed below:

<u>Title</u>	Completion Date
Río Grande de Arecibo, P.R.	1972
Rios Bayamon and Hondo, P.R.	1973
Rio Caguitas, P.R., Floodway	1974
Río Cibuco, P.R., Floodway	1974
Río Espíritu Santo, P.R., Floodway	1976
Rio Fajardo, P.R.	1973
Río Grande de Loíza, P.R., Floodway	1975

Source: Water Resources Development by the U.S. Army Corps of Engineers in Puerto Rico and the U.S. Virgin Islands, South Atlantic Division, U.S. Army Corps of Engineers, January 1979.



SOURCE: USGS, FLOODS IN PUERTO RICO, MAGNITUDE AND FREQUENCY, WATER RESOURCES INVESTIGATIONS 78-141 JUNE 1979

<u>Public awareness</u>. Only in recent years has the basic information on flood hazards been used to develop reliable floodplain maps and made available to government agencies. However, the maps and easily understood supporting information are still not made readily available to the general public.

Currently, information on flood hazards gets to the public in limited ways:

- The State Civil Defense Agency and the American National Red Cross distribute general information on the dangers of locating in a flood hazard area, but this information does not receive widespread distribution, nor does it help an individual to determine if he is located in, or about to locate in, a flood hazard area. Many of the public information materials are available only in English language editions (see Figure 10). Civil Defense also prepares about 100 press releases each year.
- Under the National Flood Insurance Program, banks must inform potential home or business owners who are borrowing federally insured money if they are located in a flood hazard area. This requirement, however, operates as a limited deterrent to locating in the floodplain since the individual usually receives the notification only after a commitment to purchase has been made. Also, it provides no information to those already living in the floodplain or to those who do not finance with federally insured funds.
- Public hearings are held by the Planning Board when flood zone maps for Planning Regulation Number 13 are adopted. FIA publishes official notices of proposed regulatory flood elevations and holds public meetings before Flood Insurance Rate Studies are adopted. These public notices and hearings afford an opportunity for individuals to learn if their homes or businesses are located in a floodable area.
- The Planning Board, on at least one occasion, arranged for the Puerto Rico Electric Power Authority to distribute with its monthly billings an FIA public information pamphlet on hurricane awareness.
- Other agencies, such as the Corps of Engineers and National



Figure 10: Examples of Public Information Materials

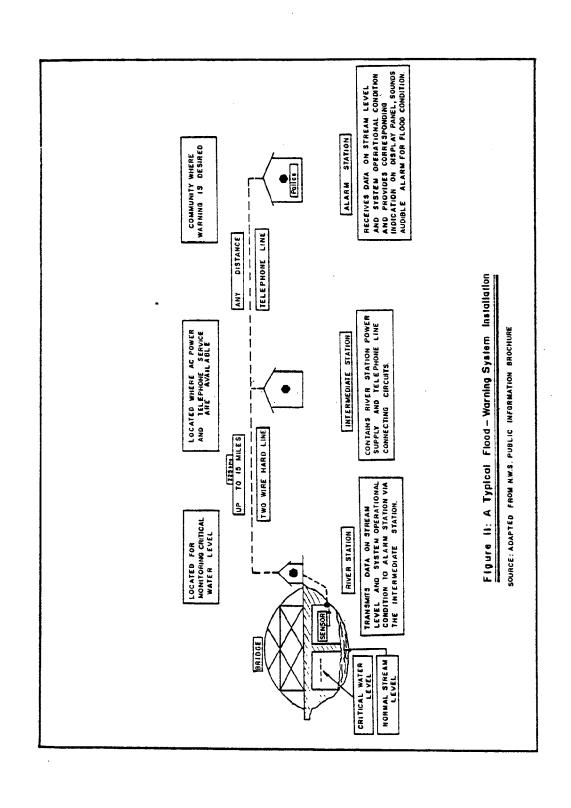
- Weather Service, distribute limited information concerning flood hazards.
- Finally, many individuals learn of the location of flood hazard areas and the dangers of living in those areas by actually experiencing a flood.

Flood Forecasts and Warnings

Flood forecast systems provide information on the time of occurrence and magnitude of flooding to be expected. When forecasts indicate an immediate threat of flooding, warnings are issued which enable both floodplain residents and government agencies to take appropriate actions before the flood occurs. If residents of a flood hazard area are warned sufficiently in advance of the likelihood of a flood occurring, they can evacuate their homes or businesses, move some possessions to upper levels of the structure, or take other appropriate actions. The effectiveness of flood warnings depends upon the effectiveness of their dissemination to the public, the time available, and the actions taken in response.

The National Weather Service (NWS) is responsible for issuing weather forecasts and flood warnings and for providing assistance to communities in establishing flood warning systems. The NWS maintains a rainfall measurement network with daily readings at about 100 stations across Puerto Rico, plus 20 continuous recording automatic rain gauges around the Island. Hurricane, flash flood, and other emergency weather warnings are immediately transmitted to the State Civil Defense Agency, radio, press and television outlets, as well as being broadcast to the public on NOAA Weather Radio (PBS Ban-VHF 162.4 mz).

The National Weather Service has also established a program for providing advanced warning of flash flooding to towns situated along rivers and creeks. Flash Flood Alarm Systems are now installed at three flood-prone towns on the Island — the first on Río Humacao to protect the town of Humacao; the second on Río Guanajibo to protect the towns of San German, Hormigueros and parts of Mayaguez; and the third on Río Portugues to protect the Ponce area. Figure 11 shows a typical flash flood alarm system. Each system is comprised of three "stations": a river station (where water level is to be monitored); an intermediate station (to connect to power and telephone lines); and



an alarm station (located in the town, with audible and visual alarms).

The Flash Flood Alarm Program is a cooperative one in that the NWS provides and installs the equipment (valued at around \$5,000) and performs maintenance for the first two years. The local community is responsible for initial and recurring utility costs, maintenance after the first two years, continuous monitoring of the Alarm System display panel, and taking appropriate actions in the event of a flood. There are no current plans to expand this program.

Tax Adjustments

Tax adjustments at the federal and Commonwealth level may play a limited role in influencing decisions about floodplain occupancy. Tax provisions can be used to encourage appropriate land use and discourage inappropriate use.

At the present time, there is no provision for using tax adjustments as incentives to avoid locating in the floodplain or to relocate outside the floodplain.

ASSESSMENT OF MEASURES TO REDUCE SUSCEPTIBILITY

The recent adoption by the Planning Board and the Department of Natural Resources of official public policies concerning the protection of developed flood hazard areas and avoidance of development in undeveloped flood hazard areas is an important and positive step toward adequate flood hazard management. Since the policies are relatively new and not fully tested, it is too soon to determine the extent to which they will serve as a general guide to public actions affecting flood hazard areas.

Since the objectives and policies themselves are not directly enforceable, it is necessary to make sure that agency regulations and programs, which are enforceable, conform to the objectives and policies. A thorough review should be undertaken by each agency of its regulations, programs, and operating guidelines to bring them into conformance with the Planning Board's official objectives and policies.

Planning Board regulations, especially Planning Regulation Number 13, should also be thoroughly reviewed and changed as necessary to conform to the objectives and policies and to make other needed changes and clarifications. In particular, Planning Regulation Number 13 needs to be revised to provide improved definitions of the three flood zones and other terms and to relate these to the zones shown on FIA's Flood Insurance Rate Maps. Also, specific building standards or other options to address floodproofing should be explored and incorporated into the regulations.

Although considerable progress has been made in the last few years on floodplain mapping, it is essential that detailed mapping of flood hazard areas be completed as quickly as possible. Maps for all flood hazard areas that clearly identify floodways and floodable zones 1, 2, and E under Regulation Number 13 must be readily available. Without these maps, many other measures aimed at reducing susceptibility to flood damage will be less than fully effective.

Although it is now Commonwealth policy to avoid development in floodplains whenever possible, the limited building space outside floodplains
will inevitably force additional development within flood hazard areas.

In addition, large segments of flood hazard areas -- including floodways -are already developed. Floodproofing offers one of the few opportunities
to reduce flood damages to buildings and public infrastructure in these
areas.

Only limited use has been made of floodproofing to date, and very little information is available to aid those who would like to provide floodproofing. A major effort should be initiated to develop and make available information on a variety of floodproofing techniques appropriate to Puerto Rico's flood hazard and construction practices. In addition, as mentioned earlier, Planning Regulation Number 13 should specify acceptable floodproofing methods.

Improved public awareness is another area that offers considerable opportunities for avoiding damages and disruption caused by flooding. The

actions of individuals can be as important as those of government in minimizing injuries and damages when floods threaten their homes and businesses, and in avoiding flood hazard areas altogether. But, before the public can take effective actions, they must be aware of the potential hazards and the options that are available to them for dealing with the hazard.

Current public awareness efforts of Commonwealth and federal agencies in Puerto Rico are insufficient. Distribution of information to the public is haphazard; it is not complete information, nor does it reach a large share of the population subject to flood hazards.

Some of the information that is distributed is inappropriate, particularly English language pamphlets produced by federal agencies and distributed directly by those agencies or by Commonwealth agencies. Some of the public information pamphlets contain information and illustrations clearly not applicable to flood hazard conditions in Puerto Rico. Although some of these materials have been translated into Spanish, the translations have not always been appropriate for use in Puerto Rico.

A concerted effort is needed by several Commonwealth agencies -- with federal agency support -- to develop and carry out a complete public awareness program. Public awareness materials must be appropriate, and they must be systematically distributed to reach the affected public directly and indirectly using a variety of public and private media.

Flood forecasts and warnings have improved markedly over the past few years. Unfortunately, it appears that future advances will take longer and be less dramatic. The climate and topography in Puerto Rico place severe limits on both the advance time and the accuracy of flood forecasts and warnings. Many of the techniques that have been developed on the U.S. mainland are not transferable to Puerto Rico.

The greatest hope for improved flood warnings seems to lie at the community level to educate floodplain residents to heed the flood warnings that are issued and to develop local Flash Flood warning systems.

MANAGEMENT STRATEGY 2: CONTROL OF FLOODING

This strategy includes all the traditional structural techniques to modify flood flows:

- dams and reservoirs
- dikes, levees and floodwalls
- channel alterations
- high flow diversions and spillways
- detention systems
- land treatment measures

These measures have been repeatedly effective in protecting property and lives, though in some instances they have also encouraged unwise development of the floodplain. Although they continue to be a strategy of floodplain management, future measures to modify floods will usually be accompanied by measures to modify the susceptibility to flood damages.

Planning for control and management of water resources, including flood control, was originally a responsibility of the Planning Board. During the early 1960's, the Planning Board contracted for a number of flood control studies, using Section 701 planning funds from the Federal Department of Housing and Urban Development.

As a result of these studies, a number of flood control projects were implemented by the Department of Transportation and Public Works (and its predecessor) without federal participation. Among the flood control projects constructed by Puerto Rico are the flood control channels of Rio de Bayamon in Bayamon, Cataño and Toa Baja; Rio Yagüez in Mayagüez; and Rio Humacao in Humacao. The flood control works on the Rios Portugues and Bucaná in Ponce were initiated by the Government of Puerto Rico and are now being implemented jointly with the Corps of Engineers.

The Planning Board conducted other flood control studies that have not yet been implemented. These studies relate to Río Manatí at Barcloneta and Manatí and Río Guanajibo at Cabo Rojo, Hormigueros and Mayagüez. The Puerto Rico Aqueduct and Sewer Authority and the Puerto Rico Electric Power Authority (formerly the Water Resources Authority) have constructed dams and operate reservoirs for water supply and hydroelectric power, but these reservoirs have not been used for flood control purposes.

Individual municipalities and private developers have also performed studies and constructed flood control projects, primarily stream channelization, drainage systems and levees.

In 1972 responsibility for flood control planning works was transferred to the Department of Natural Resources, Water Resources Bureau. Most major flood control studies are now performed by DNR and the Corps of Engineers as cooperative studies, or by the Corps of Engineers at the request of DNR.

Although flood control planning activities were transferred to DNR, the Department of Transportation and Public Works, Flood Control Area, retained responsibility for designing, building, and maintaining flood control works. The DTPW has seven regional offices which carry out the construction and maintenance of flood control works. Currently four projects are under construction by the Commonwealth:

- channelization of the lower part of Rio Hondo (Bayamon)
- channelization of Quebrada Mendoza (Cabo Rojo)
- channelization of Rio Humacao (Humacao)
- channelization of Ríos Portugues and Bucaná (Ponce), in cooperation with the Corps of Engineers (see below).

Through the years, Puerto Rico has relied on channelization as the principal structural measure for flood protection. Channel improvements are particularly applicable on the urbanizing coastal floodplain, where the cost of developed land and the lack of suitable reservoir sites upstream preclude the use of reservoirs or other structural measures. Construction of storm sewer systems and floodwalls are other flood control projects frequently undertaken by DTPW.

The Government of Puerto Rico also conducts cooperative studies with the Corps of Engineers and the Soil Conservation Service. Although many flood control studies have been jointly conducted by Puerto Rico and the COE or SCS or by the federal agencies at Puerto Rico's request, few projects have

These responsibilities were transferred to DNR in 1972 but were transferred back to DTPW in 1973. A transfer to DNR is expected again in 1980; Staff and resources from DTPW will also be transferred to DNR.

been constructed. Brief descriptions of the flood control studies and projects involving federal agencies are provided below.

The Corps of Engineers, in cooperation with Puerto Rico, is currently constructing two flood control and water supply dams and making channel improvements in the Ponce area:

Rios Portugués-Bucaná multipurpose project is currently under construction. This joint Commonwealth-Corps project, which will provide protection to the city of Ponce from a 500-year flood and a dependable water supply of about 33.8 million gallons per day, was authorized in three parts by the Flood Control Act of December 30, 1970: Portugués Dam and Reservoir, Cerrillos Dam and Reservoir, and channel improvements at Ponce. Both dams will be about 250 feet high and will store water for flood control, water supply, and recreation. The channel project calls for enlargement of 7.6 miles of Río Portugúes and Río Bucaná through Ponce with a 1.1 mile flood diversion channel from Río Portugués to Río Bucaná. The total cost of the project is estimated at approximately \$22 million. Estimated annual costs total \$14,490,000. The first construction phase -- channelization of the lower reaches of Rio Bucaná -- was started in June 1975 and finished in October 1976. The second phase - further channelization of Rio Bucana, and construction of a diversion channel between Río Portugues and Río Bucaná -began in June 1976 and was completed in September 1978. The third phase is now under construction. Estimated completion date for the entire project is 1986.

The COE has conducted a number of other flood control studies that have not resulted in project authorization:

- Río Chico a study to provide facilities for protection against flooding; discontinued as not feasible.
- Río de La Plata a study to provide facilities for protection against flooding; study completed in 1978, not feasible. A new study is scheduled to begin in 1981.
- Río Fajardo a study to consider provision of initial flood control works; will begin in 1980 as part of a Puerto Rico/ Virgin Islands water supply pipeline study.

U.S. Army Corps of Engineers, <u>Water Resources Development in Puerto Rico</u> and the U.S. Virgin Islands, March 1977.

U.S. Army Corps of Engineers, Water Resources Development by the U.S. Army Corps of Engineers in Puerto Rico and the U.S. Virgin Islands, January, 1979.

Correspondence, U.S. Soil Conservation Service, San Juan, Puerto Rico, 1979.

- Río Valenciano a study to provide facilities for protection against recurrence of flood conditions resulting from heavy rains such as those which accompanied Hurricane Donna in 1960; study completed in 1977, not feasible. Will be reviewed under the Río Grande de Loiza study.
- P.R. Drainage Basins and Coastal Areas a cooperative study to address problems of water quality, flood control, wastewater, water supply, inadequate public recreation, surface transportation, and inadequate housing patterns; completion date is indefinite.
- Ponce Regional Water Resources Study (information to follow).
- Río Puerto Nuevo a study to address extensive flooding in a highly urbanized sector of the San Juan Metropolitan Area. Expected completion in 1980.
- Río Grande de Loíza a study to examine the extensive flooding and erosion problems on the largest watershed in Puerto Rico. First phase completed in 1978. Final completion expected in 1981.
- Small flood control studies in the areas of Sabana Grande, Penuelas, Arroyo, Mariaco, and Río Coamo.

The Corps of Engineers has also conducted several beach erosion control studies:

- a plan to protect and improve a 0.9 mile area at Condado, through beach nourishment; inactive.
- a study to consider measures to stabilize the shore from Punta Salinas to Arecibo; inactive.
- a study to determine needed corrective measures at El Tuque Beach west of Ponce. Study completed in 1978 with a recommendation for federal involvement, but lack of a suitable source of beach fill material has delayed the project.
- a study to aid in beach improvements and park protection at Punta Salinas; expected to begin design and construction during FY 80.

The Soil Conservation Service, which primarily serves rural areas in small river basins (up to 250,000 acres) focuses on limiting flooding by controlling upstream runoff through land treatment, soil conservation, and some structural measures. SCS operates through local soil conservation districts and under cooperative agreements with Commonwealth agencies and municipal governments in the installation of flood control works in small, non-urban watersheds to reduce erosion, floodwaters, and sediment discharge.

Most SCS construction projects are funded through the Small Watershed Program (P.L. 566). Current and proposed projects are:

• Añasco River Watershed Project. First authorized in 1962 and expected to be completed by 1982, the project covers 129,128 acres. The floodplain, which is the area to be benefitted, encompasses around 7,500 acres in the municipalities of Mayagüez and Añasco. The project includes land treatment and structural measures. The estimated cost is \$5.9 million (\$2.6 million in P.L. 566 funds and \$3.3 million in other funds). Major problems to be resolved are floodwater damage to agricultural land and the need for improved drainage.

The first step of this project, completed in 1972, was 10 miles of channel improvements of La Boquilla Unit, which represents about 16 percent of planned structural measures. The Rio Daguey Unit includes one flood-retarding structure and channel work. SCS has completed the final designs for the dam and prepared the landrights maps for the flood detention structures and channels. The Commonwealth Department of Natural Resources has obtained landrights and has relocated those affected. SCS has contracted for construction of the dam. Construction will start in November 1979. Landrights maps for the remaining structural measures were sent to the Department of Natural Resources in December of 1978, and, as soon as these landrights or easements are secured, remaining structures can be built.

• Guayanes River Watershed Project at Yabucoa. The Guayanes project, which would dover 31,700 acres, is designed to reduce floodwater damage to agricultural land and residential areas and to improve drainage. It was originally authorized in 1963; the expected date of completion is uncertain. The estimated total cost was \$4.3 million in 1963 -- \$2.7 million in P.L. 566 funds and \$1.6 million in other funds. Today, total cost is estimated at \$40 million. About 90% of the accelerated land treatment measures have been applied.

The SCS Director reactivated this project in 1971, in response to renewed local interest following the floods of October 1970, when up to 35 inches of rain fell on parts of the watershed over a 5-day period, causing considerable damages. The project plan was originally developed to provide agricultural protection for the floodplain, but due to the development of industries and urbanization, there is need to increase the level of flood protection. At the request of local sponsors, SCS is now revising the plan to reflect these changes in objectives and land use on the floodplain. The first draft of the Guayanes River Watershed Work Plan and EIS was circulated among local, Commonwealth, and federal agencies.

• Bajura Watershed Project. The Bajura project includes 86,835 acres in the municipalities of Cabo Rojo, Hormigueros, Mayagüez, and San Germán. Originally authorized in 1963, the project was estimated to cost \$6 million -- \$4.5 million in P.L. 566 funds and \$1.5 million in other funds. Current estimate is \$50 million. The completion date is uncertain. About 45% of the accelerated land treatment measures have been applied.

The Commonwealth Department of Natural Resources, the main sponsor for the project, requested a work plan revision to deal with the extensive damages caused by tropical storm Eloise. A re-evaluation of the project feasibility was made and concurrence by DNR to initiate the proposed revision is pending. However, SCS has not decided whether it will continue its planning effort.

• "El Caribe" Resource Conservation and Development Project. The "El Caribe" RC&D project was approved for USDA assistance on September 10, 1979. This project encompasses 789,354 acres. The total area lies in 5 Soil Conservation Districts. The western boundary of the project is the political limits of the Municipality of Añasco. The eastern boundary is the political limits of the Municipality of Maunabo. The north boundary is the limits of the Oeste, Suroeste, Caribe, Sur and Sudeste Soil Conservation Districts. The south boundary is the Caribbean Sea.

The objectives of this locally sponsored RCSD are to improve the use of the area's natural resources; improve and expand economic, cultural, and recreational opportunities for local residents; and to enhance the environment. The "El Caribe" RCSD Council has initiated action toward the preparation of the Plan Design, which is the initial plan for the area. Among the eligible measures for RCSD financial and technical assistance are flood prevention, critical area treatment for erosion and sediment control, farm irrigation, and land drainage.

SCS has proposed several other projects. Two were approved for planning in 1962 — the Rio Maunabo Watershed and Yaurel Watershed projects; draft work plans were prepared shortly after, but no further planning has taken place. The application for the Rio Culebrinas Watershed was approved in 1963, but further action was delayed. A new plan may be developed in response to renewed interest.

ASSESSMENT OF FLOOD CONTROL MEASURES

Large segments of Puerto Rico's floodplains are fully or partially developed. Limited flood control has been accomplished through stream channelization, storm drainage systems, levees, and small flood and erosion control dams. Large flood control reservoirs have not been used. Most flood control studies performed by the Corps of Engineers have not resulted in a favorable benefit/cost analysis.

As detailed mapping of flood hazard areas is completed, however, some review of past flood control studies may be appropriate to determine if conditions have changed significantly. This is particularly important where floodplain mapping is showing portions of major urban areas to be located in floodways, as in Guayanilla and Toa Baja. Development of flood control structures may be the best method of providing protection to these highly developed areas.

Additional channelization and construction of new or improved storm drainage systems are needed in many areas. Proper maintenance of existing systems is of major importance. Consideration should be given to using existing reservoirs for flood control purposes as well as water supply.

MANAGEMENT STRATEGY 3: MINIMIZE THE IMPACT OF FLOODING ON INDIVIDUALS AND THE COMMUNITY

A third strategy consists of actions designed to reduce the impact of flooding on both individuals and the community. No matter now effective other strategies are, these measures will have a role to play. Many are relatively new. Implementation rests primarily with the Commonwealth and its municipios, though the federal government plays a major financial and technical support role.

Flood Insurance

Insurance is a mechanism for spreading the cost of losses both over time and over a relatively large number of similarly exposed risks. Under the National Flood Insurance Program, initiated in 1968 and significantly expanded in 1973 and 1977, the federal government subsidizes flood insurance for existing property in the flood hazard area in return for community enactment and enforcement of floodplain management regulations.

The National Flood Insurance Program (NFIP) is operated by the Federal Insurance Administration (FIA), part of the Federal Emergency Management Agency (FEMA). In Puerto Rico, the Planning Board serves as the coordinating agency for the Flood Insurance Program. Puerto Rico entered the Emergency Phase of the Flood Insurance Program in 1972 and

the Regular Phase of the Flood Insurance Program in August 1978.

The Regular Phase of the Flood Insurance Program offers higher levels of insurance coverage to participants. In order to move from the Emergency Phase to the Regular Phase, more stringent floodplain regulations must be enacted than are acceptable for the Emergency Phase. More detailed data on flood hazards is also needed to provide a base for the regulations.

Puerto Rico entered the regular program following the revision of Planning Regulation Number 13 (discussed previously) and completion of preliminary Flood Insurance Rate Maps (FIRM's). (See Figures 7 and 8) For purposes of the Flood Insurance Program, Puerto Rico is considered a single community by FIA.

Under the regular program, floodplain residents are eligible for subsidized insurance on their principal residence for up to \$35,000 and up to \$10,000 on the contents of their home. An additional \$150,000 of coverage for the structure and \$50,000 for contents are available at actuarial rates. Insurance for new construction or buildings that are "substantially improved" is available at actuarial rates. Table 2 shows available insurance coverage for eligible properties.

Flood insurance is obtained through private insurance agencies. Information on the availability of flood insurance is provided to home and business owners through their insurance agents or through informational leaflets distributed in utility billings. For additional information, individuals may contact the local office of EDS Federal Corporation which handles insurance policies and claims for FIA, or the Flood Insurance Coordinator in the Planning Board. There is also

l. The federal government pays a substantial portion of the actual cost.

²"Substantial improvement" means any repair, reconstruction, or improvement of the structure, the cost of which equals or exceeds 50% of the market value of the structure.

Table 2: Maximum Amounts of Insurance Available Under the National Flood Insurance Program

	First Layer ¹ Maximum Amount at Subsidized or Actuarial Rate ²	Second Layer ³ Maximum Additional Amount at Actuarial Rates	TOTAL COVERAGE
BUILDING			
Single Family	\$ 35,000	\$150,000	\$185,000
(Exceptions: Alaska, Hawaii, Guam, Virgin Islands)	(50,000)	(135,000)	(185,000)
All Other Residential	100,000	150,000	250,000
(Exceptions: Alaska, Hawaii, Guam, Virgin Islands)	(150,000)	(100,000)	(250,000)
Small Business	100,000	150,000	250,000
All Other Structures	100,000	100,000	200,000
CONTENTS			
Single Family	10,000	50,000	60,000
All Other Residential	10,000	50,000	60,000
Small Business ⁴	100,000	200,000	300,000
All Other Structures	100,000	100,000	200,000

NOTES

Source: National Flood Insurance Program, Flood Insurance Manual, Federal Insurance Administration, 1978.

Maximum insurance available under the Emergency Program for structures in existence on and not substantially improved after December 31, 1974, or before the effective date of FIRM (Flood Insurance Rate Map), whichever is later. Use subsidized rates.

²Under the Regular Program for existing structures use subsidized rate or actuarial rate, whichever is lower. For structures located in an identified special flood hazard area which are newly constructed or substantially improved after December 31, 1974, or the effective date of FIRM, whichever is later, use actuarial rates only.

³ Second layer insurance is available under the Regular Program only. Use actuarial rates.

⁴"Small Business" for the purpose of the National Flood Insurance Program describes any concern having (with its affiliates) assets not in excess of \$5,000,000, net worth not in excess of \$2,500,000 and an average net income after Federal income taxes, for the preceding two years not in excess of \$250,000 (computed without carryover loss).

a toll-free number (800-424-9080) operated by FIA in Washington, D.C. which can be called to obtain information, in English and Spanish, on the Flood Insurance Program.

The number of flood insurance policies in force in Puerto Rico reached a peak of more than 9,000 following Tropical Storm Eloise in 1975.

Many policies were later allowed to lapse, however, and in March 1979, only 5,127 policies were in force. Flooding from storms "David" and "Frederic" in September 1979 caused a second surge of purchase of flood insurance policies. By the end of December 1979, slightly over 10,000 policies were in force.

Adequate flood insurance can be extremely valuable to persons whose property is damaged in floods by helping them avoid financial disaster. Flood insurance is also relatively inexpensive when purchased at federally subsidized rates. Even so, the minimum insurance premium, \$25 per year, can be a financial burden for many lower income residents.

Government buildings (but not infrastructure such as highways and bridges) are also eligible for federal flood insurance. To date, Puerto Rico has not purchased flood insurance for government buildings. A program is now underway to map all government buildings and determine their value, so that a decision can be made whether the government of Puerto Rico should purchase federal flood insurance or set up a self-insurance program for government buildings.

Tax Adjustments

Tax adjustments can help in a small way to ease the financial losses associated with floods. Persons sustaining flood losses may be able to receive a tax deduction as a casualty loss, for any portion of flood losses that are not covered by flood insurance.

Puerto Rico tax law allows a special income tax deduction for losses, not compensated for by insurance or other form of compensation, to a primary residence caused by hurricanes (and fires and other casualties). Another special deduction, limited to \$5,000, is also allowed for losses to automobiles, furniture, and other household

goods caused by hurricanes, storms, tropical depression, flooding, and earthquake. Similarly, the loss must not be covered by insurance or other compensation, and must have occurred in an area designated by the Governor as eligible to receive aid under disaster assistance programs. Specific information on claiming casualty losses from floods can be obtained from the Puerto Rico Internal Revenue Office.

Flood Emergency Measures and Post-flood Recovery

Emergency measures, including contingency and emergency floodproofing, for instance, can be put into effect in anticipation of flooding for areas where warning time would permit these actions. Other emergency measures include rescue operations, evacuation and provision of shelter, and additional emergency relief options. One of the functions of overall flood hazard management is to reduce the need for emergency actions.

Post-flood recovery provides for restoration of public facilities and services and provides aid to individuals. Although relief does not directly reduce flood losses, it can reduce the impact of the loss by shortening the period of disruption and by accelerating the return to normalcy.

The Puerto Rico State Civil Defense Agency has been designated by Law Number 22 of June 1976 as the agency responsible for coordinating the activities of all Commonwealth agencies in response to emergencies and disasters. The responsibilities of the State Civil Defense Agency and 21 other Commonwealth agencies were detailed in Executive Order 3532: Coordination of Executive Functions In Case Of Disasters, signed by the Governor July 3, 1978. This Executive Order was revised during 1979 and issued as Administrative Bulletin Number 3669 on August 22, 1979.

Among the responsibilities of the State Civil Defense Agency are:

- coordination of emergency drills and warmings.
- preparation of a contingency plan for the suspension of public services (water, gas, electricity, transportation, etc.) during emergencies.
- supervision of the relocation of population in flood-prone areas (or flooded areas) during emergencies in designated areas and/or shelters.

- coordination with the Department of Education for the utilization of schools (public or private) as shelters during emergencies.
- immediate clean up and restoration of vital services.
- coordination of public, non-profit, and private efforts for the care of the physical and emotional needs of the citizens.
- preparation of recovery and redevelopment plans for the replacement, reconstruction, removal, and relocation of damaged or destroyed facilities and services.

A summary of the responsibilities of other Commonwealth agencies is provided in Table 3.

Puerto Rico has been divided into seven zones by the State Civil
Defense Agency (see Figure 12). A Civil Defense Coordinator is assigned
within each zone, and is responsible for coordinating Civil Defense activities with the mayors of the municipios in the zone, and for supervising local Civil Defense activities. There are Zone Emergency
Committees composed of all government agencies with emergency responsibilities within each zone. During emergencies, activities are
coordinated through a Zone Emergency Operating Center.

All municipios have local Civil Defense organizations, including Municipal Emergency Committees. The local groups are expected to meet periodically to evaluate local emergency resources — specifically before the hurricane season, and at other times as necessary.

During 1976 and 1977, using grants from the Federal Disaster Assistance Administration (FDAA)¹, the State Civil Defense Agency (formerly called the Office of Civil Defense) developed an emergency preparedness plan titled The Commonwealth of Puerto Rico Emergency Operations and Disaster Control Plan. The plan is intended to serve as a basis for coordinated actions for Commonwealth agencies during flood emergencies or disasters, as well as other types of disasters including earthquakes, fire and any other catastrophes.

In April 1979 FDAA became part of the Federal Emergency Management Agency (FEMA) under the name Office of Disaster Response and Recovery (ODRR).

Table 3: Summary of Commonwealth Agency Responsibilities During Emergencies and Disasters

Agency

Power

Telephone Authority

Emergency Responsibility

Department of Education Provision of food for refugees; coordinate with the Dept. of Housing to use schools as shelters if no other shelters are available; assist

when necessary in conducting a census of the affected population in

rural areas.

Provision of shelters and temporary or permanent housing for displaced Department of Housing

persons (including the federal Temporary Housing Program); coordinate

with the Red Cross in administering the shelters.

Department of Health Provision of emergency health services.

Department of Social Provide necessary social services during and after each emergency; ad-Services

minister the federal program for provision of emergency food stamps and

the federal Individual and Family Assistance Program.

Department of Conduct a census of damages to roads, highways, ports, bridges, etc. Transportation and and make recommendations for rehabilitation of transportation facilities;

Public Works verification of damage reports on transportation facilities.

Police Maintenance of law and order; protection of life and property; verify

and report on damages to persons and property.

National Guard Develop and maintain plans to aid civil authorities as needed; mainten-

ance of law and order.

Puerto Rico Electric Restoration of electrical service; coordinate with DTPW in highway

cleaning and repair, and with Civil Defense on emergency communications.

Aqueduct and Sewer Restore potable water supplies in affected areas; coordinate cleaning of Authority sewers.

tions Authority and Civil Defense in emergency communications.

Compile information on the population affected; administer Emergency Department of Labor

Centers that are established; administer the federal unemployment

Restore potable water supplies in affected area; assist the Communica-

assistance program.

Direct and supervise fire suppression; assist PRASA in providing potable Fire Department

water to affected areas.

Communications Restore service in affected areas; assist the Telephone Authority and Authority Civil Defense in emergency communications.

Vigilance; conservation of rivers, beaches, other waters and forests; Department of

Natural Resources preparation of hazard mitigation plans.

Department of the Treasury Administer the State Emergency Fund and federal disaster assistance funds.

Department of Commerce Prepare an inventory of supplies and cooperate with Consumer Affairs in

controlling prices and supplies of goods.

Department of Consumer Affairs Enforce price controls.

Department of Agriculture Conduct an inventory of agricultural damages.

General Services Facilitate transport and purchase of excess property; acquisition of

Administration needed equipment, food supplies, etc.

Economic Development Report to the Governor on damages to industrial plants and estimate on Administration costs and time for repairs or reconstruction, inventory of industrial

buildings that can be used as shelters.

Coordinate the conservation and restoration of public recreation facili-Public Recreation and

Parks Administration ties; report on damages to parks and other facilities.

Source: Administrative Bulletin No. 3669: Governor's Executive Order for Courdination of Executive Functions in Case of Disasters: August 22, 1979.

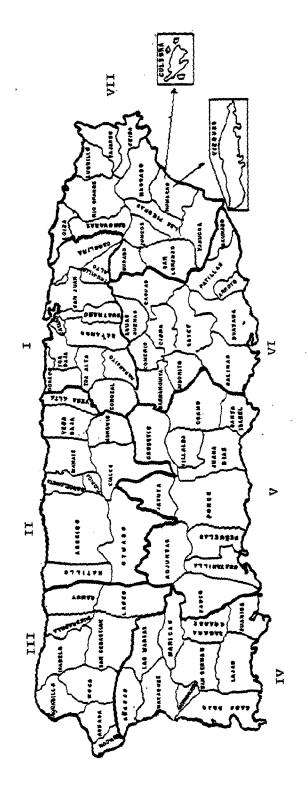


FIGURE 12: PUERTO RICO OFFICE OF CIVIL DEFENSE OPERATION ZONES

According to the Civil Defense plan, each government agency and municipio is to develop, and annually revise, an emergency operations plan, including damage impact assessment procedures. The Office of Planning Assistance and Resources, within the State Civil Defense Agency, is responsible for providing guidance and assistance in developing these plans. New or revised plans were scheduled to be submitted to the State Civil Defense Agency in May 1979, but none were actually submitted. The State Civil Defense Agency is not currently pressing for submittal of these individual agency plans because it is revising the Emergency Operations and Disaster Control Plan in response to the recent executive orders.

All official information to news media and other concerned institutions during flood emergencies is provided by the Office of Emergency Information and Community Relations within the State Civil Defense Agency. It provides information on civil defense and disasters to the media at other times as well.

According to the Emergency Operations Plan, post-flood reconstruction or new construction must be in agreement with redevelopment plans, which are to be prepared by Civil Defense, and "take into account the effect of the disaster and shall make appropriate provisions to assure that similar disasters do not occur insofar as possible."

Funds to provide for emergency services and post-flood recovery are granted through the Emergency Fund, which was created by Public Law No. 91 of 1966.

When a flood disaster is of such magnitude that Commonwealth resources are inadequate to deal effectively with the problem, the Governor may request the President, through the Federal Emergency Management Agency (FEMA), to declare the affected portion of Puerto Rico a disaster area.

If FEMA and the President agree that federal resources are needed, the President makes the disaster declaration and designated FEMA as the agency responsible for coordinating all federal disaster assistance efforts. FEMA establishes temporary offices in Puerto Rico and works

jointly with the State Civil Defense Agency in coordinating the activities of the federal and Commonwealth agencies involved in flood fighting, emergency relief efforts, and other types of flood disaster assistance.

There have been five Presidentially declared flood disasters in Puerto Rico in recent years. These occurred in:

August 1956 - Hurricane Betsy (Santa Clara)

October 1970 (60 municipios) - Tropical Depression

October-November 1974 (52 municipios)

September 1975 (Islandwide) - Tropical Storm Eloise

September 1979 (72 municipios) - Hurricane David and

Tropical Storm Frederic

Federal programs coordinated by FDAA (now ODRR) during flood-related emergencies or disasters in Puerto Rico include:

National Weather Service (NWS) emergency weather broadcasts flood emergency relief (flood Corps of Engineers (COE) fighting and rescue operations) emergency conservation measures Agricultural Stabilization and Conservation Service (ASCS) Soil Conservation Service (SCS) emergency flood protection emergency loans Farmers' Home Administration (FMHA) search and rescue operations; pro-Coast Guard vision of clothing, food, and shelter to persons rescued mobile home financing; property Department of Housing and Urban Development (HUD) improvements school construction and maintenance Department of Health, Eduassistance cation and Welfare (HEW)

Veteran's Administration adjustments to federal loans

General Services Administra- equipment and facilities
tion (GSA)

Food and Nutrition Service emergency food stamps (FNS)

Small Business Administration emergency loans (SBA)

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Tropical Storm Frederic

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emergency weather broadcasts National Weather Service (NWS) Corps of Engineers (COE) flood emergency relief (flood fighting and rescue operations) emergency conservation measures Agricultural Stabilization and Conservation Service (ASCS) Soil Conservation Service (SCS) emergency flood protection emergency loans Farmers' Home Administration (FMHA) search and rescue operations; pro-Coast Guard vision of clothing, food, and shelter to persons rescued Department of Housing and mobile home financing; property improvements Urban Development (HUD) school construction and maintenance Department of Health, Education and Welfare (HEW) assistance Veteran's Administration adjustments to federal loans equipment and facilities General Services Administration (GSA) Food and Nutrition Service emergency food stamps (FNS) emergency loans Small Business Administration (SBA)

The Federal Emergency Management Agency directly provides three basic types of post-flood recovery assistance as part of its disaster relief services:

- Individual and family grants. FEMA provides grants, which may not exceed \$5,000, to individuals or families for repairing, replacing, rebuilding or providing access to private residences. The Governor administers the program which is 75 percent federally-funded, and 25 percent state-funded. If Puerto Rico is unable to pay its 25 percent share, it can receive an advance.

Individuals needing assistance must apply to the State Civil Defense Agency. Applicants must first seek all other available governmental assistance.

- Public assistance. FEMA awards grants for repairing, restoring, reconstructing, or replacing a facility, based on its design immediately before the disaster and in conformity with applicable current codes and standards, including flood insurance regulations. Commonwealth and municipio governments and private, non-profit organizations are eligible for assistance.

Public assistance grants are made available to repair, replace, or reconstruct public facilities using one of three formulas:

- (a) categorical grant. (100 percent of the cost of restoring each facility to its preflood condition, plus costs to conform to NFIP reconstruction standards)
- (b) flexible funding. (a lump sum equal to 90 percent of the combined cost of restoring all damaged facilities in a community)
- (c) in-lieu grant. (an unrestricted 100 percent lump sum grant if total community-wide damage is \$25,000 or less)
- Temporary housing. Individuals and families whose houses are made uninhabitable by a major disaster (or if access to the house is restricted or essential services are interrupted) are eligible for temporary housing assistance. Temporary housing may be provided in several forms, including vacant habitable dwellings, rental housing, mobile homes or other readily fabricated dwellings. Responsibility for furnishing the site and utilities is assigned to the owner of the site, the occupant of the temporary unit, or the municipio or Commonwealth government. If it is in the public interest, the federal government will provide sites and utilities. Rent is not charged for the first 12 months of occupancy.

Funds are available under the minimal repair program as a replacement for temporary housing where owner-occupied private dwellings can be quickly restored to habitable condition at minimal cost.

The federal government has often been criticized for using these programs to simply restore facilities to their pre-flood condition -- leaving them just as vulnerable to the next flood. Current regulations, however, require that all reconstruction conform to floodplain regulations established under the National Flood Insurance Program.

Hazard Mitigation

Hazard mitigation covers all actions that can be taken to reduce the flood hazard on the impacts of flooding. It is often expressed in terms of actions that should be taken immediately following serious flooding, but it also includes actions that can be taken at any time.

FEMA issued regulations in November 1979 to encourage comprehensive hazard evaluation and mitigation of future flood hazards. These regulations provide that, following a major disaster, FEMA will provide technical assistance through a joint Federal-Commonwealth team, which will identify and evaluate the impacts of hazards in the disaster area, and recommend measures to mitigate the hazards. The team will evaluate existing plans for hazard mitigation with particular attention to the adequacy of warning and evacuation plans. FEMA may prescribe hazard mitigation regulations or construction standards as a condition of federal disaster assistance grants or loans. (For example, a grant or loan to rehabilitate a damaged facility could be denied unless the facility was relocated from the hazard area.)

The regulations also provide that the Governor's Authorized Representative will be responsible for designating a State Hazard Mitigation Coordinator to serve on the Federal-Commonwealth survey team. The State Coordinator will be responsible for follow-up to assure that timely Commonwealth hazard mitigation actions are taken and to arrange for financial or technical assistance required to accomplish hazard mitigation actions.

The Department of Natural Resources was designated as the agency responsible for hazard mitigation planning by the Governor's Executive Order (Administrative Bulletin 3669) of August 22, 1979.

Following flooding from Hurricane David and Tropical Storm Frederic in September 1979, the President declared 72 of Puerto Rico's 78 municipalities as disaster areas eligible for federal assistance. As part of the Federal-Commonwealth Agreement governing the provision of federal disaster aid, Puerto Rico agreed to conduct hazard mitigation planning.

In fulfillment of this requirement, the Department of Natural Resources established a Hazard Mitigation Task Force and a Hazard Mitigation Work Group, each composed of representatives of Commonwealth and federal agencies, to assist with the preparation of hazard mitigation plans. A work program was developed that provided for the preparation of hazard mitigation plans for two target areas (coastal floodplains of Río Grande de Loíza and Río de La Plata) and a general plan for all of Puerto Rico. These plans are scheduled for completion in mid-1980.

ASSESSMENT OF MEASURES TO MINIMIZE FLOOD IMPACTS

The National Flood Insurance Program has not yet been implemented to the extent needed. To date, only a small percentage of eligible individuals and businesses have taken out flood insurance, and many of these have failed to renew policies purchased in order to receive disaster assistance. Because so much development has occurred in flood hazard areas, serious or repeated flooding is inevitable, and flood insurance should be used to maximum advantage to help alleviate the financial burden imposed by flooding.

Limited sales of flood insurance policies may be partially due to insufficient public awareness of its availability. A check with FIA revealed that the toll-free number available for information flood insurance has been little used. The Planning Board has placed notices in newspapers concerning the availability of flood insurance, but more intensive public awareness efforts may be needed.

Another possible reason for limited purchase of flood insurance may be cost. Even though the insurance is made available at subsidized rates, it may still

be unaffordable for many low income residents. Some consideration has already been given to having the Commonwealth government subsidize the cost of flood insurance normally carried by the individual. This concept needs to be explored further.

Emergency measures and post-flood recovery operations appear to be functioning reasonably well, given the difficult circumstances under which they are conducted. An area of possible improvement is the individual emergency operations and recovery plans that are required of each agency. Continuing assessment of the entire program of emergency preparedness is essential.

Hazard mitigation activities are not well organized or even well understood. Hazard mitigation has received new emphasis at the federal level in recent months, but the interest has not yet been translated into functioning programs and guidance. Much remains to be accomplished in the area of hazard mitigation at both the federal and Commonwealth levels.

PART III. MOVING TOWARD A COORDINATED PROGRAM OF FLOOD HAZARD MANAGEMENT

Findings

The first two parts of this report have looked at existing conditions: at the nature, frequency and severity of the flood hazards in Puerto Rico, and at how both the general population and Commonwealth and federal agencies are responding to those hazards. Three broad findings result.

THE FLOOD HAZARD IN PUERTO RICO IS SEVERE

Severe flooding can result from landfalling hurricanes, hurricanes that pass nearby but do not actually hit the Island, and from non-hurricane storms. Almost every part of the coast is subject to flooding from either flash floods or from coastal surges, and many parts of the interior are subject to flash floods.

Although flashflooding may be predicted, Puerto Rico's relatively small size and many small drainage basins that divide the island prevent geographically detailed predictions of the occurence of flash flooding. As a result, the warning time available is usually a matter of only hours, or even minutes.

Prediction of storm surges affecting the near shore areas is also uncertain. The state-of-the art for storm surge prediction is less well developed than for flash floods, and there has been only limited study of storm surges affecting Puerto Rico.

Over the past 100 years, the types of damages incurred from flooding have changed somewhat. Personal property damage has greatly increased as personal wealth has grown, and damages to infrastructure, particularly roads and bridges, have increased as development has spread. However, fewer deaths have resulted from recent major floods and fewer buildings

have been destroyed in those floods. Improved warning systems have greatly contributed to the reduced loss of life. Changes in construction materials and practices probably account for much of the reduced structural damage.

Nevertheless, the potential for property damage and loss of life is higher than it has ever been: there is a much greater population living in hazard areas now than at any time in the past. The next major hurricane to directly strike Puerto Rico could cause enormous property damage, economic and social disruption and substantial loss of life.

THERE IS INSUFFICIENT AWARENESS OF THE FLOOD HAZARD AND OF WHAT CAN BE DONE TO REDUCE THE HAZARD AND ITS IMPACTS

Minor flooding occurs frequently and residents of many areas appear to accept this flooding as largely unavoidable. Unfortunately, this casual attitude also seems to extend to more serious flooding, with many people, and even some government agencies, underestimating the danger of major floods.

The public, in general, is not sufficiently aware of the location of flood hazard areas, the severity and frequency of flooding that may be expected in those areas, and of what they as individuals can do to reduce their susceptibility to the flood hazard. This lack of awareness stems in part from the inadequacy of government efforts to provide the public with information about flood hazards and to educate them in the informed use of that information.

Although government agencies have greater access to flood hazard information than do individuals, they too are sometimes not sufficiently aware of the location of flood hazard areas. The flood hazard information base that has been developed is inadequate for many of the island's flood hazard areas. Even for locations where adequate information has been developed, only a part of that information may be readily accessible; the remainder may be scattered among various departments of Commonwealth and federal agencies. Additional information is also found in environmental impact statements and in studies prepared for residential, commercial, and industrial development projects.

Where flood hazard areas have been fully delineated, there still may be a lack of knowledge or awareness of the severity of the hazard; frequency of flooding, depth and velocity of floodwaters, duration of flooding, etc. This kind of detailed information on the nature of the hazard has not yet been developed for most flood hazard areas. Even where it has been fully or partially developed, many government agencies are unaware of it.

In summary, both among the general public and within government agencies responsible for responding to flood hazards, there is insufficient awareness of the nature of flood hazards and what can be done to reduce the impacts of flooding.

A COORDINATED PROGRAM OF FLOOD HAZARD MANAGEMENT DOES NOT CURRENTLY EXIST IN PUERTO RICO

Puerto Rico government agenies are not organized to respond in the most effective manner to flood hazards. Although many agencies are involved in different ways with responding to flood hazards, collectively they are not using all measures available to them, nor are they making full use of the measures they do employ.

Through the years, various government agencies have been assigned -- by law and by Executive Order -- responsibilities for discrete aspects of flood hazard management. Many agencies have also added other flood hazard management activities that relate naturally to their principal mission. Given this ad hoc approach, there has been a remarkable success in dealing with flood hazards. Nevertheless, the ad hoc approach prevents the Commonwealth from responding to flood hazards with its full potential.

A systematic evaluation of Puerto Rico's approach to flood hazards has not been undertaken before. Consequently, a coordinated approach for responding to flood hazards has not been designed and implemented. The absence of such a coordinated program of flood hazard management prevents Puerto Rico from identifying all of the potential resources at its command and using those resources to maximum advantage. Instead, agencies generally implement flood hazard management activities independently of one another. This approach results in failure to act in important areas. At times,

agency activities may actually work at cross-purposes. Seldom are the actions of one agency fully supported by the actions of others.

The federal government operates a number of programs that can be used directly and indirectly to respond to flood hazards. Without a coordinated program for flood hazard management, Puerto Rico is not in a position to recognize and use these federal resources in a way that maximizes their flood hazard management potential in support of Commonwealth programs.

Absence of a coordinated program for flood hazard management has contributed to flood losses in Puerto Rico. Only limited action has been taken to reduce the flood hazard. Often government actions have permitted — and sometimes even promoted — inappropriate development in flood hazard areas. Absence of a coordinated government program is also a factor in the lack of public awareness.

CONCLUSION: PUERTO RICO NEEDS TO DEVELOP A COORDINATED FLOOD HAZARD MANAGEMENT PROGRAM

A firm legal base for a coordinated flood hazard management program needs to be established, and a single agency needs to be assigned the primary flood hazard management role so that it can perform many of the necessary activities and coordinate the actions of other agencies.

Recommendations

Following are a number of recommendations that, if implemented, will move Puerto Rico toward development of a coordinated program of flood hazard management — the kind of program that is essential if Puerto Rico is to deal effectively with its severe and increasing flood hazards and with the complex array of potential resources for responding to the hazard.

ISSUE AN EXECUTIVE ORDER FOR FLOOD HAZARD MANAGEMENT

To reduce conflict and confusion over agency responsibilities for a coordinated program of flood hazard management, a clear legal base for such a program needs to be established. The two principal choices for establishing this legal foundation are by legislation and executive order.

Because development and passage of legislation is often a protracted process, it is recommended that, initially, an executive order be issued. The executive order should state the purposes and principles of a coordinated flood hazard management program and define responsibilities of the affected government agencies. The recent Executive Order 3669 concerning coordination of emergency disaster aid provides a useful model. If needed, legislation can be developed at a later date to replace the executive order.

DESIGNATE AN AGENCY TO COORDINATE THE FLOOD HAZARD MANAGEMENT PROGRAM

It is not necessary, nor even desirable, to consolidate all flood hazard management responsibilities within one agency. But, if Puerto Rico is to effectively carry out a coordinated flood hazard management program, a single agency must be designated as the lead agency for conducting much of the flood hazard management work and for coordinating the activities of the other agencies.

Because of the broad and significant responsibilities already assigned to the Department of Natural Resources, it is recommended that DNR be designated, in the executive order, as the lead agency for flood hazard management and that the Department take an active role in coordinating the flood hazard management responsibilities of other Commonwealth agencies.

By law, DNR has responsibility for flood control planning, and it was recently assigned, by executive order, responsibility for hazard mitigation planning. During 1980, flood control construction, operation and maintenance responsibilities will be transferred to DNR from the Department of Transportation and Public Works (DTPW). These duties, together with the Hydrologic Data Bank which DNR maintains, comprise a very significant part of the total flood hazard management program.

INCREASE THE EFFECTIVENESS OF ONGOING FLOOD HAZARD MANAGEMENT ACTIVITIES

Many current flood hazard management activities should be continued with little or no change. Nevertheless, a periodic reevaluation of these activities is necessary to insure that they continue to support the developing flood hazard management program.

In addition, inadequacies in some present flood hazard management activities of Commonwealth and federal agencies have been identified. These need to be carefully evaluated and follow-up actions taken to effect improvements. Each affected agency must be involved in the evaluation, but DNR, as the coordinating agency, should take the lead in initiating these evaluations and seeing that they are completed within a reasonable time frame. Recommendations resulting from the evaluations should be implemented by appropriate agencies. DNR should monitor their progress.

Agency Regulations and Operating Procedures Should Be Refined, Coordinated and Enforced

Continuing development of floodplains, and even of some high hazard areas, is evidence that current agency regulations and procedures are either inadequate or not being properly enforced. Sometimes such development results from conflicts between program purposes. In other instances, the requirements of intent of a regulations may be unclear, making it difficult for the agency to act effectively. Illegal development has also occurred, with government agencies unwilling or unable to take the necessary legal actions to prevent such development.

Probably the most important step in controlling unwise development in floodplains is improved enforcement of agency regulations and procedures. Even so, individual agency programs must work in support of one another, and not at cross-purposes as they sometimes do now. The regulations and procedures that define these programs must also be clearly written. Revisions to some agency programs are needed if these objectives are to be achieved.

• Each Puerto Rico agency should be required (by the executive order) to review its own regulations, programs and operating guidelines to determine if they conform to the Planning Board's Objectives and Public Policies for Land Use, and to the purposes and principles of a coordinated flood hazard management program, set out in the executive order. The evaluation should also examine the possible need for clarification of regulations and operating procedures. Each agency should proceed to make any necessary changes.

Responsible Agencies:

Each Commonwealth agency with flood hazard management responsibilities (Should be specified in the executive order)

Planning Regulation Number 13 provides an example of the kinds of changes that agencies need to make to their regulations and operatine procedures:

- Planning Regulation Number 13 should be revised as follows:
 - -- Specific building standards or other options to address floodproofing should be identified and incorporated into Planning Regulation 13, either directly or by reference.
 - -- Definitions of Zones 1, 2 and Special E should be related to FIA's Zones A, B and C, and V.
 - -- Other definitions such as floodway, provisional floodway, and regulatory flooding should be redefined for clarity and to conform with the definitions used in the National Flood Insurance Program.
 - -- Consideration should be given to establishing an additional zone, outside the official V-zone, identifying areas potentially subject to wave run-up.

Responsible Agency: Planning Board

- Planning Regulation Number 13 should be more stringently enforced.

Responsible Agencies:

Planning Board
Regulation and Permits Administration
Department of Natural Resources
Department of Housing

Each agency's evaluation and recommended changes should be submitted to DNR for review. DNR should insure that there are no conflicts among agency programs.

Responsible Agency: Department of Natural Resources

 Guidance should be developed which can be used by agencies in reviewing and commenting on projects proposed for development in floodplains.

Responsible Agency: Department of Natural Resources

Continued Efforts Are Needed To Clearly Identify Flood Hazards

Although enormous progress has been made during the last few years in mapping Puerto Rico's flood hazard areas, the job is not yet complete. Since detailed knowledge of flood hazard areas is a basic requirement to proper response to flood hazards, continuation of this effort is of great importance.

 The established program of preparing Flood Insurance Rate Maps (FIRM's) should continue and should be completed as quickly as possible.

Responsible Agency:

Federal Insurance Administration, with the assistance and cooperation of the Planning Board, the Corps of Engineers, U.S. Geological Survey and the Department of Natural Resources

 Regulatory Floodways should be established and delineated for all areas covered by Planning Regulation Number 13.

Responsible Agencies:

Planning Board, and Department of Natural Resources, with the assistance of the Corps of Engineers and the U.S. Geological Survey

 Additional information on the extent of wave run-up needs to be developed in coastal high hazard areas and added to Planning Regulation Number 13 maps and Flood Insurance Rate Maps.
 Responsible Agencies:

Federal Insurance Administration, and Planning Board, with the assistance of the Corps of Engineers, the U.S. Geological Survey and the National Weather Service

 Mapping of historical floods should be continued and accelerated since knowledge of the extent of historical floods is a primary source of data for delineating flood hazard areas.
 Responsible Agencies:

Department of Natural Resources, and Planning Board, with the assistance of the U.S. Geological Survey

• DNR should continue a cooperative program with the Corps of Engineers to prepare flood hazard information reports for selected river basins. Information about the flood hazard in particular geographic areas needs to be collected and made readily available to government agencies, private developers, and residents of the areas.

Responsible Agencies:

Department of Natural Resources, with the assistance of the Corps of Engineers

An inventory should be completed of residences, commercial establishments, and industries located in flood hazard areas.
 Responsible Agencies:

Department of Housing, and Puerto Rico Industrial Development Company

• An inventory should be completed of government buildings located in flood hazard areas, including their value. The inventory will permit Puerto Rico to determine if it should purchase flood insurance or develop a program of self-insurance.

Responsible Agency: Department of Transportation & Public Works (Bureau of Public Property)

 Flood control studies should be undertaken or earlies studies reevaluated where flood hazard maps indicate substantial development located in high hazard areas.

Responsible Agencies:

Department of Natural Resources, and Planning Board, in cooperation with U.S. Geological Survey and the Corps of Engineers

Additional Flood Warning Systems and Evacuation Plans Are Needed

Broad scale flood forecasting and warning systems are currently effective throughout Puerto Rico. However, localized flash flood warning systems have been installed in only three locations on a trial basis. Evacuation procedures from flood hazard areas vary among municipalities and are often informal. A more uniform and systematic system of localized flood warning and evacuation is needed.

 Additional flash flood warning systems should be installed where feasible, and local government officials trained in their operation and maintenance.

Responsible Agency:

State Civil Defense Agency, and Municipal Governments, with assistance and cooperation from the National Weather Service

 Release of flood waters from water supply reservoirs should be coordinated with flood warning systems and evacuation plans.
 Responsible Agencies:

Aqueduct and Sewer Authority Electrical Power Authority State Civil Defense Agency

• In communities where they do not already exist, detailed evacuation plans should be prepared that clearly specify areas most susceptible to flooding, the conditions under which evacuation should occur, the means by which residents should safely leave the area, and means of notification for safe return to the area. Responsible Agencies:

State Civil Defense Agency, and Municipal Governments, with assistance from the Corps of Engineers

Improved Public Awareness Of Flood Hazards Is Essential To Reduce Flood Damages and Disruption

There is insufficient awareness of flood hazards by the citizenry in Puerto Rico. Responsibility for informing the public is spread among

several agencies, but efforts have not been coordinated. In order to reduce the likelihood of a major catastrophe, greater public awareness of both the hazards posed by flooding and of possible responses is needed.

• Residents of flood-prone areas should be provided, both directly and indirectly, with more information about flood hazards and possible responses. Public media notices, for example, should be used as an indirect means of notification. Door-to-door distribution of pamphlets explaining the flood hazards in specific locations is an example of how residents of specific flood hazard areas can be directly informed.

Responsible Agencies:

State Civil Defense Agency
Department of Natural Resources
Red Cross

- The public needs to be made more fully aware of the availability, costs, and benefits of flood insurance.
 Responsible Agency: Planning Board
- The public, private developers, and government agencies need to be made aware that the Coastal High Hazard Zone (V-Zone) -- currently being designated on FIA Flood Insurance Rate Maps -- does not include an allowance for wave run-up and therefore understates the area which would be flooded in a 100-year flood.

Responsible Agencies:

Planning Board Regulation and Permits Administration Department of Natural Resources State Civil Defense Agency

- Evacuation routes and location of emergency assistance centers should be made known to the public in advance of flooding.

 Responsible Agency: State Civil Defense Agency
- In order to satisfy all these information needs, an inventory and evaluation of existing public awareness activities should be

undertaken. The evaluation should determine where public awareness activities overlap and where an information need is not being met. Responsibilities should then be assigned to appropriate agencies so that all aspects of public awareness are covered.

Responsible Agency: Department of Natural Resources

A periodic review of the public awareness effort should be conducted to insure that the total effort is effective -- appropriate materials prepared, distributed to necessary individuals and agencies with adequate frequency and through the appropriate media -- and to make any necessary adjustments in the public awareness program.

Responsible Agency: Department of Natural Resources

Improved Recordkeeping Is Needed By All Agencies Involved With Flood Hazards

There is currently an inadequate system of recordkeeping on flood potential, actual flood occurrences, and particularly on emergency assistance and post-flood recovery. Readily available, accurate records are one key to proper flood hazard management planning and coordination of agency activities.

• More complete records of types and amounts of damage that occurred during flood emergencies and disasters should be kept.

Responsible Agencies:

All agencies involved with damage assessments

Complete and accurate records of the types and amounts of expenditures for flood recovery should be maintained.
 Responsible Agencies:

All agencies involved with repair, reconstruction and disaster aid following flood damages

• The Department of Natural Resources, as part of its coordinating role, should maintain a central file of records and data relating

to all aspects of flood hazard management.

Responsible Agency: Department of Natural Resources

INITIATE NEW FLOOD HAZARD MANAGEMENT ACTIVITIES

There are some flood hazard management activities that have not been used to any significant degree in Puerto Rico. A few of these should clearly be initiated. Others are less clearly suitable for use in Puerto Rico and require further investigation before a firm decision can be reached regarding their value as part of Puerto Rico's flood hazard management program.

Post-Flood Hazard Mitigation Activities Should Be Undertaken

The immediate post-flood period sometimes provides unique opportunities to reduce vulnerability to future floods; many existing structures must be repaired or rebuilt, a variety of federal and Commonwealth funds become available only at this time, and both the public and government agencies are usually more receptive to changes than they are under more normal circumstances. Puerto Rico has recently recognized this opportunity and responsibility by designating DNR as the lead agency for hazard mitigation planning required by federal programs. Puerto Rico should take further advantage of this opportunity by:

- Preparing and implementing site-specific hazard mitigation plans for the most severely damaged areas.
- Prepare an islandwide hazard mitigation plan, including a contingency plan to immediately initiate hazard mitigation activities following a flood.

Responsible Agencies:

Department of Natural Resources, with the cooperation and assistance of many Commonwealth and federal agencies

Regular Stream Maintenance Is Needed

• A program of regular stream maintenance should be initiated. While limited maintenance is currently undertaken where streams have been

channelized, and in connection with certain COE and SCS projects, many stretches of unimproved streams are currently unmaintained, raising flood stages considerably. The impact is especially significant during high frequency (1- to 10-year) floods. While a program of stream maintenance would not greatly reduce damages from severe floods, it could have a major impact on damages from smaller floods, at a relatively low cost.

Responsible Agencies:

Municipal Governments, and Department of Natural Resources, assisted by the Corps of Engineers and Soil Conservation Service

The Following Measures Should Be Studied For Adoption As Appropriate

• Commonwealth subsidies to flood insurance: Even though the cost of flood insurance is low, many Puerto Ricans either cannot afford to or will not purchase it. Because the benefits of flood insurance are so considerable in relationship to the costs, Puerto Rico should investigate possible Commonwealth subsidies for or outright purchase of insurance for low-income residents.

Responsible Agency: Department of Social Services

• Technical assistance for floodproofing: The applicability of floodproofing techniques in Puerto Rico should be investigated.

A how-to manual for those techniques that are applicable should be prepared and distributed.

Responsible Agencies:

Regulation and Permits Administration, and Planning Board, with the assistance of the Corps of Engineers

• Financial assistance for floodproofing: The appropriateness of a Commonwealth program of financial assistance for floodproofing should be investigated following identification of floodproofing measures recommended for local use.

Responsible Agencies:

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Planning Board Department of Housing Puerto Rico Industrial Development Company • Tax incentives: A program of tax incentives for both individuals and businesses should be explored that would provide for tax benefits if residences or businesses are voluntarily relocated out of high hazard areas (V-zones and designated floodways).

Responsible Agencies:

Department of Treasury
Planning Board
Department of Housing
Department of Natural Resources

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SUPPLEMENT

HURRICANE DAVID AND TROPICAL STORM FREDERIC

AUGUST 30 TO SEPTEMBER 6, 1979

A PRELIMINARY ACCOUNT OF DAMAGES AND RESPONSES

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Introduction

The most recent severe flooding to affect Puerto Rico occurred during the 1979 hurricane season when the island was affected by two major storms during a five-day period. Hurricane David passed 100 miles south of Puerto Rico on August 30th, and Tropical Storm Frederic cut through the center of the island on September 4th.

These storms occurred while this report on coastal hazard management was in draft stages. While the flooding and flood damages were obviously very difficult for those affected, the storms presented an excellent opportunity to enhance the data presented in the report. The opportunity to collect up-to-date and accurate information -- particularly on emergency and post-flood recovery activities -- allowed a current perspective on Puerto Rico's overall response to the flood hazard.

Hurricane David

Hurricane David developed in the tropical Atlantic Ocean on August 26th. Aircraft reconnaissance of David began on the afternoon of August 27th. From then on David was tracked continuously by aircraft and satellites. Several changes in David's track occurred as it approached the Windward Islands. The first turn was on August 27th from an almost due west track to a more west-northwest track that spared the island of Barbados and shifted the impact to islands further north.

On Tuesday, August 28th, the possibility of danger to Puerto Rico from Hurricane David was reported as "unlikely". Late on August 28th David shifted to a slightly more northern track, and the eye passed between the islands of Martinique and Dominica around noon on August 29th. The forward motion of

David was named by the National Weather Service as a Tropical Storm on August 26th, and was increased to hurricane intensity on August 27th, solely on the basis of satellite photographs. Similar decisions were made also in the case of Hurricane Frederic several days later.

the storm was then around 15 mph. Dominica was completely devastated by David with over 60,000 if the island's 80,000 residents left homeless.

By Wednesday evening, the 29th, a hurricane warning and a flash flood warning had been issued for Puerto Rico and the Virgin Islands, and local newspapers published articles on how to prepare for a hurricane. Hurricane David — with 115 mph sustained winds and gale force winds extending 150 miles from the center — was soon being touted as the most dangerous hurricane to threaten Puerto Rico since Donna in 1960. Later reports warned of an even more dangerous storm, potentially comparable to San Felipe in 1928.

The storm was projected to pass about 60 miles south of Ponce and 50 miles south of Cabo Rojo with 75 mph winds affecting Puerto Rico. During the night of August 29-30, the track of the storm shifted slightly further south of Puerto Rico than previously anticipated. Although the final path was 100 miles to the south, the entire island felt the effects of the storm.

The biggest threat from a near-miss hurricane for Puerto Rico is the heavy flood-producing rainfall. Floodwaters began to rise in some areas by Thursday evening, August 30th. Severe flooding occurred over the east, south, and north sections of Puerto Rico during the early morning and during the day of August 31st. Rainfall for the 3-day event was around 20 inches in the central mountainous sector of Cayey-Cidra, 19 inches in the southwest corner, 2-10 inches in the north coastal area, and 6-10 inches in the south central coastal areas. (See Figure 1)

Coastal flooding is a serious but less predictable threat from a near-miss hurricane. The NWS issued a coastal flood warning at 10:30 p.m. on August 29th, and recommended to Puerto Rico officials that low lying areas in the east and south be evacuated as a precaution against possible storm surges. Considerable damage did occur from coastal flooding.

On August 30th, the Puerto Rico Civil Defense Agency set up its command center in San Juan. To facilitate response to the emergency, desks for each of 10 agencies plus the Red Cross were provided in the command center. All rescue operations were coordinated from the Civil Defense command center.

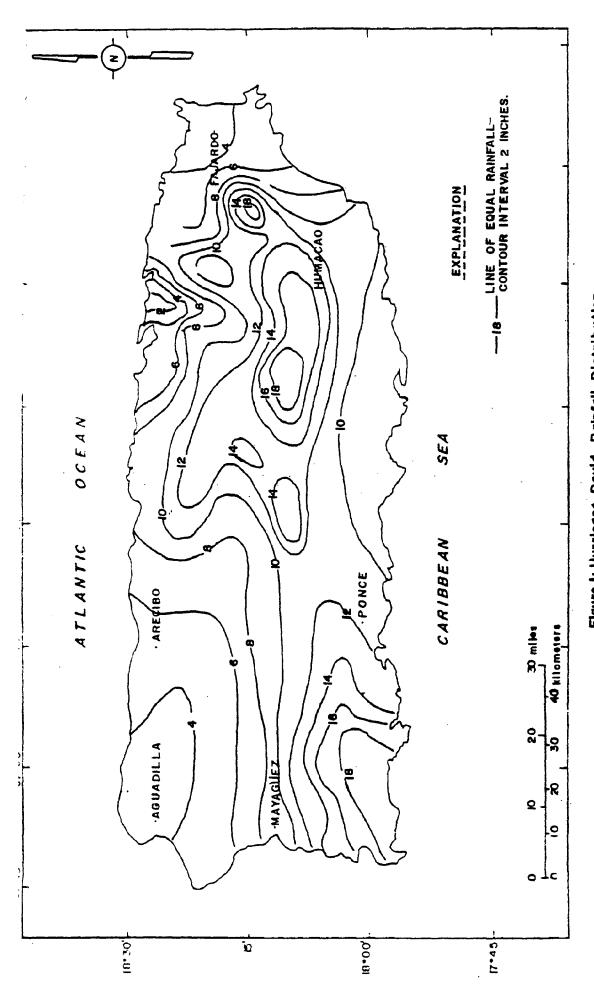


Figure 1: Hurricane David, Rainfall Distribution

SOURCE: USGS, FLOOD IN PUERTO RICO, MAGNITUDE AND FREQUENCY, WATER RESOURCES INVESTIGATIONS 78-141 JUNE 1979

Evacuation of floodplain residents began on August 30th. In Toa Baja, one of the hardest hit areas, 15,000 residents were evacuated to shelters that night.

Some difficulties in evacuation procedures were reported. Some residents in the Río Grande de Loíza area refused to leave their homes in anticipation of the hurricane's approach. In other areas, authorities were criticized for giving evacuation warnings too late. Some Toa Baja residents had to be rescued from roof-high waters and brought to shelters Thursday night.

By Friday, August 31st, the death toll reached six with major flooding reported in at least nine towns. Twenty thousand refugees were in shelters Friday afternoon, and 30,000 by nightfall.

The Governor declared a state of emergency on Friday, releasing \$3 million in emergency aid and activating the National Guard. The Governor also requested a federal disaster declaration. A 15-member team of officials from the Federal Emergency Management Agency (FEMA) regional office in New York arrived in Puerto Rico on Friday to assess damages. The Red Cross also flew in a 7-member disaster team.

A Presidential disaster declaration was made on Sunday, September 2nd, and the acting director of FEMA's Region II Office was named Federal Coordinating Officer for federal disaster assistance. The original declaration affected only six municipalities -- Ponce, Arecibo, Humacao, Arroyo, Barceloneta and Manatí. These areas were the first to be assessed for damages. As damage estimates for other towns were made, additional areas were covered by the disaster declaration.

Initial estimates of damages from Hurricane David due to both flooding and wind were as follows:

The final death toll was 7, much less than early reports. Several people unaccounted for turned up later. Of the 7 deaths, 3 occurred in Toa Baja from loose electric wires; another in Guaynabo was caused by electric wires; a man in San Sebastian was killed by a falling tree; 2 persons drowned.

- \$55 million lost in agricultural production and equipment (including a 50 percent loss of the coffee crop valued at \$26 million and a 60 percent loss of the plantain crop at \$17 million). Much of the agricultural loss was caused by high winds.
- 80 percent of rural aqueducts and 35 percent of urban aqueducts inoperable.
- 53 towns without water service.
- 30 percent of the island without electric power.
- over 800 houses destroyed and more than 8,000 damaged.
- 25 percent of the roads blocked by floods, landslides, or fallen trees.

Tropical Storm Frederic

As the cleanup and assistance efforts continued, a second storm moved toward Puerto Rico. Tropical Storm Frederic developed on August 30th, well out in the tropical Atlantic. It moved west initially, turning on August 31st to a west-northwest track. At noon on September 1st it was upgraded to hurricane intensity.

The first advisory issued by the NWS in San Juan was at 6:00 a.m. September 2nd. The center of the system passed north of Antigua and very close to Barbuda before noon on September 3rd. Gale winds with higher gusts were experienced at both islands.

Sunday evening, September 3rd, a hurricane watch was issued for Hurricane Frederic. On Monday, refugee centers began to reopen. Municipal trucks and jeeps equipped with loudspeakers travelled through potential trouble spots announcing the possibility of evacuation. Low-lying sectors of La Perla were evacuated as were some part of Toa Baja. A Civil Defense technician accompanied the President of the Hotel Association to advise hotels to take appropriate measures.

The storm was originally projected to pass about 100 miles north of Puerto Rico on Tuesday morning. The National Weather Service warned of severe

flooding because of the already-saturated condition of the soil, and since flood waters from Hurricane David's rains had not completely receded in some areas.

As Frederic approached Puerto Rico, it was barely maintaining hurricane intensity, and by midnight of September 4th, it was downgraded to Tropical Storm Frederic. At the same time, a slight change in its direction occurred which took the storm south of St. Thomas and into eastern Puerto Rico, just north of Fajardo, about 8:00 Tuesday morning. The storm continued westward across Puerto Rico during the day and exited just north of Mayaguez in mid-afternoon. (See Figures 2 and 3) Frederic's winds were not as strong as David's -- sustained winds of 40-50 mph -- and wind damage was minimal. Heavy swells generated by a strong southeast flow behind the storm center caused beach erosion and damage to roads. Waves of 12 to 15 feet occurred on the east and south coasts. Heavy rains continued after the storm passed. A rainfall distribution map for Frederic (see Figure 4) shows that the northwest portion of Puerto Rico was hardly affected.

Some difficulties in evacuating people were again reported. For example, some residents of Toa Baja refused to leave in advance of actual flood conditions -- even in areas which had just experienced flooding during Hurricane David.

Many schools and community centers throughout the island were used as refugee centers. Unoccupied buildings were also made available to Civil Defense by PRIDCO for use as shelters. As the initial stages of the storm passed, however, some refugees in schools were transferred to other buildings, such as community centers and government buildings. Through the emergency phase of

The occurrence of Hurricane Frederic right after Hurricane David was of great historical significance. Frederic was the third tropical cyclone to affect Puerto Rico in the 1979 season (after Claudette and David). In the history of cyclones in Puerto Rico such a well-documented triple event in one season has not been recorded since 1530, a span of about 450 years. The occurrence of 2 cyclones at short intervals between each other has a precedent in Puerto Rico about 200 years ago. According to history records, there were cyclone attacks on the island on August 28th and August 31, 1772. Those 2 cyclones of 1772 had been viewed previously with suspicion, but after the David (August 30th)-Frederic (September 4th) event of 1979, they are more believable. Source: NWS



2 A September 1, 1979



2 A September 4, 1979

Figure 2 Satellite Photos of Hurricane David and Tropical Storm Frederic

Source: National Weather Service

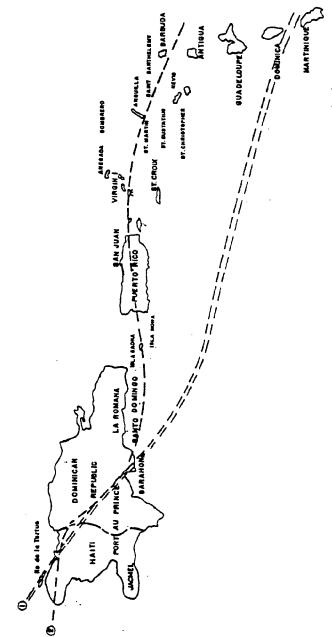


Figure 3: Paths Of Hurricane David and Tropical Storm Frederic

HURRICANE (1) DAVID AUGUST 29, 1979

TROPICAL STORM

(2) FREDERIG SEPTEMBER 4,1979

SOURCE: N.W.S. NATIONAL WEATHER SERVICE

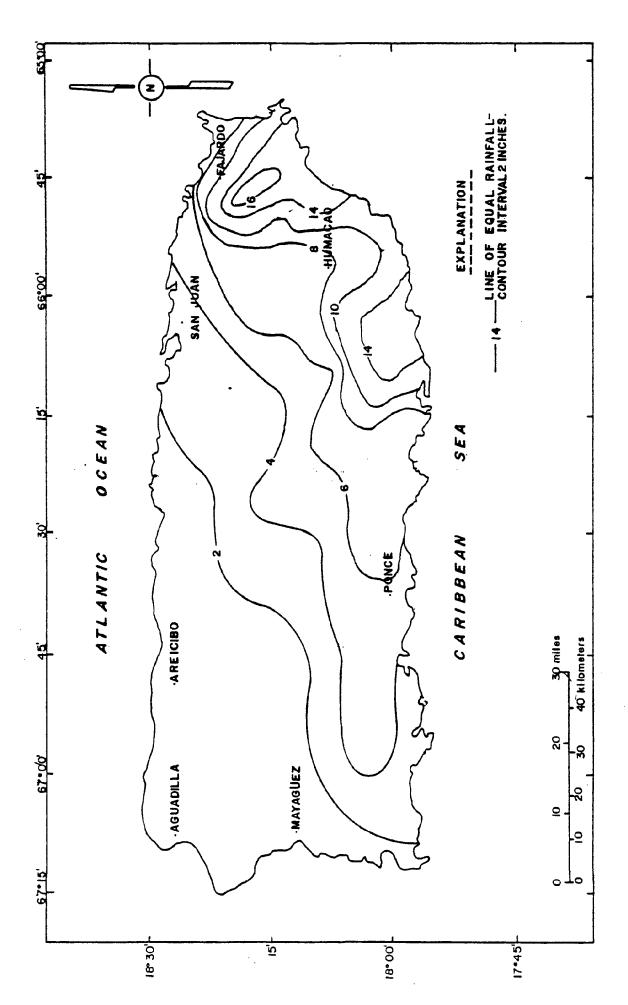


Figure 4: Tropical Storm Frederic, Rainfall Distribution

SOURCE: USGS, FLOOD IN PUERTO RICO, MAGNITUDE AND FREQUENCY, WATER RESOURCES INVESTIGATIONS 78-141 JUNE 1979.

the storms, the State Civil Defense Agency coordinated the actions of all government agencies through its main information center, with agency representatives present on a 24-hour basis. An Emergency Broadcast System was activated several times (although some radio stations did not join the broadcast).

Damages and Disaster Assistance

The day after the second storm hit, FEMA announced that damages from Tropical Storm Frederic would be covered under the disaster declaration made following Hurricane David. Damage assessments proceeded quickly (FEMA increased its on-island staff to between 40 and 50 by hiring local residents on a temporary basis), and by September 6th 15 municipios were included in the disaster declaration, making residents eligible to receive federal disaster relief. The first of a series of daily meetings of local and federal officials at FEMA offices was held to identify needs and organize relief. A Federal/Commonwealth Agreement on Disaster Assistance was signed on September 7th. Commonwealth agencies were asked to submit plans by Saturday, September 8th, on disaster assistance needed. Within a week, 42 municipios were covered by the disaster declaration. A federal advance of \$1 million was deposited in a special Department of Social Services account with the Treasury Department.

The Federal Emergency Management Agency (FEMA), in cooperation with the State Civil Defense Agency, moved to establish eight one-stop emergency management centers (EMAC's) to bring the relief services of 16 agencies under one roof. The centers were to be located in factories or public facilities in disaster areas. All 8 EMAC's were established within a week of the second storm. In addition, the Red Cross opened 27 relief centers around the island to distribute \$3 million in aid to 8,000 families.

The Department of Social Services issues and distributes checks to storm victims.

The emergency management centers were originally managed jointly by FEMA and Commonwealth officials. After operating procedures were established, the federal officials were withdrawn. Information on services available from the centers was published in four newspapers. 1

At the outset, approximately 4,000 people were registering each day for assistance at the centers. Registrations at these centers are shown on Table 2. By September 12th, over 10,000 residents of the 42 disaster municipios had registered for aid from the 8 regional emergency management centers. Later, one additional center opened and one was relocated. Vieques and Culebra were originally served by a mobile team, but Culebra applicants were subsequently brought to the Humacao Center by boat to register. By September 21st, thirty additional municipios were declared eligible for disaster assistance, bringing the total to 72. (See Table 1).

As noted previously, total agricultural damages were estimated at \$50 million, most resulting from the high winds during Hurricane David. Several types of assistance have been made available, including \$8.1 million in cash and materials financed by the Puerto Rico emergency aid program. This assistance takes several forms: no interest loans up to \$1,000 for holdings of less than 50 acres; free fertilizer; cash bonuses for new coffee plantings aimed at longer term rehabilitation; government purchase of some crops; and provision of coffee harvesting nets at partial cost.

Approximately 1,835 flood insurance claims were submitted. About 1,340 of these were approved and \$4,632,000 in payments made. Most claims were for contents damage rather than structural damage. Before the storms, just under 7,000 families were covered by flood insurance through the NFIP. As of December 31, 1979, 10,037 policies with a total coverage of \$205,599,300 were in force. FEMA and Puerto Rico have reached an agreement whereby approximately 52,000 new policies will be purchased by the government of Puerto Rico for persons who received disaster aid under the Individual and Family Grant (IFG) program. Funds for the insurance premiums are provided through the disaster aid grants.

By Governor's directive, all disaster-related press releases had to be cleared through the Puerto Rico Disaster press office and FEMA.

TABLE 1: MUNICIPIOS ELIGIBLE FOR DISASTER ASSISTANCE

For Individual and Public Assistance

Adjuntas Aibonito Añasco Arecibo Arroyo Barceloneta Barranquitas Cabo Rojo Caquas Canovanas Carolina Cataño Cayey Ceiba Ciales Cidra Coamo Comerío Corozal Culebra

Dorado

Fajardo Guánica Guayama Guayanilla Gurabo Hormigueros Humacao Jayuya Juana Díaz Juncos Lajas Lares Las Piedras Loiza Luguillo Manatí Maricao

Maunabo

Mayaguez

Morovis

Naguabo Naranjito Orocovis Patillas Peñuelas Ponce Río Grande Sabana Grande Salinas San Germán San Juan San Lorenzo Santa Isabel Toa Baja Utuádo Vega Baja Vieques Yabucoa Yauco

For Individual Assistance Only

Aguada Rincón San Sebastián

For Public Assistance Only

Aguas Buenas Bayamón Florida Guaynabo Las Marías Toa Alta Trujillo Alto Vega Alta Villalba

TABLE 2: REGISTRATIONS AT EMERGENCY MANAGEMENT CENTERS (EMAC'S)

Cumulative Number of Registrations for

65,972

66,532

Disaster Assistance Chronology of EMAC Operations at all EMAC's 9/2 Presidential disaster declaration made 9/8 Centers at Arroyo, Ponce, Arecibo opened 9/9 Centers at Toa Baja, Carolina, Humaca opened 4,269 9/10 . 9/11 Centers at Mayaguez and Cidra opened 7,560 11,618 9/13 Culebra and Vieques to be served by a mobile team 9/14 19,388 9/15 Center at Cidra closed; Naranjito opened 9/16 Cidra center relocated to Gurabo 9/17 9/18 Vieques center opened 9/19 Viegues center closed; Culebra residents brought 40,000 by boat to Humacao center 9/20 41,350 9/21 Toa Baja center closed 50,000 9/22. 9/23 Mayaguez and Gurabo centers closed 57,014 9/24 Arroyo center closed 9/25 9/26 Carolina and Naranjito centers closed

9/28 Ponce and Arecibo centers closed

and individual agency offices

10/5 Additional registrations made at FEMA headquarters

(all EMAC's closed)

9/27

¹ As of October 5, 1979

Housing repairs and relocation costs were estimated at \$10 million by the Department of Housing. Approximately 1,000 homes were destroyed and thousands of others damaged. Many of these families qualified for temporary housing assistance (e.g. temporary relocation in rental housing). The temporary housing program was administered through the district offices of the Department of Housing.

Other types of federal disaster assistance made available include:

- Individual and family grants, up to \$5,000, provided by FEMA to help rebuild or repair damaged houses. This is the largest cost category of the disaster assistance distributed following David and Frederic.
- Public assistance grants from FEMA to municipio and Commonwealth agencies to rebuild or repair public facilities damaged by the storms.
- Business or home loans from the Small Business Administration (SBA).
- Disaster unemployment assistance from the Department of Labor.
- Grants and loans from the Farmers Home Administration.

The estimated costs, as well as the number of applications received and approved, and funds disbursed for each type of assistance are included in Table 3.

The SBA established its emergency center in Ponce to process applications for home and business repair loans. Additional SBA offices were located throughout the island.

To familiarize local and state officials with the public assistance program, FEMA presented a film and slide presentation on application procedures, provided training sessions for locally-hired civil engineers, and held briefings for municipios and Commonwealth agencies.

TABLE 3: SUMMARY OF DISASTER ASSISTANCE

PROGRAM	ESTIMATED COST	PROJECTED APPROVALS	APPLICATIONS REC'D/APPRV'D	APPLICATIONS APPROVED (\$)	\$ DISBURSED
ECM	\$ 600,000(?)	1,000	5,811/0	0	0
DUA	1,576,000	3,700	7,711/0	0	0
EFS	127,111	1,000	2,026/682	127,111	115,410
SBAB	5,000,000	2,000	1,007/93	293,500	0
FIA	15,000,000	2,000	1,696/399	1,176,807	1,176,807
SBAH	20,000,000	5,000	9,496/327	1,104,600	0
IFG	48,500,000	32,000	39,150/13,193	16,663,990	11,268,176
FMHA	8,000,000	1,000	1,535/0	0	0
Temporary Housing	3,000,000	(see below)		4	
Public Assistance	22,016,000	(see below)			

Temporary Housing		Public Assistance	
Estimated units required Applications received	23,000 34,073	Estimated total cost	\$22,016,000
Applicants eligible	20,139	Debris clearance	1,200,000
Ineligible	5,287	Protective measures	1,300,000
Withdrew	197	Road systems	12,500,000
		Water control facilities	500,000
Eligibles assisted	18,247	Public buildings	1,200,000
-		Public utilities	5,000,000
Estimated program cost	\$3,000,000	Facil. under construction	14,000
		Private Non-profit	2,000
		Other	300,000

¹ As of October 5, 1979

Hazard Mitigation

In response to recent initiatives, a different type of flood recovery activity was undertaken following the two storms. In April 1979, the Federal Disaster Assistance Administration (now part of FEMA and called the Office of Disaster Response and Recovery) issued proposed regulations which would require the development of hazard mitigation measures as part of the disaster assistance effort. These regulations were issued as final in November 1979. The Federal/Commonwealth agreement on disaster assistance includes a provision requiring hazard mitigation planning by Puerto Rico as a condition of federal disaster aid. The purpose is to reduce the potential for recurring or similar flood damages in the future. Accordingly, the FEMA office in Puerto Rico established a mitigation section. As soon as emergency activities (provision of temporary shelter, etc.) were under control, efforts on hazard mitigation were initiated, in mid- to late-September.

The first steps were development of a preliminary schedule of mitigation procedures and a draft outline for a hazard mitigation plan. Initially, attention focused on relocation and the elevation of residences as the most appropriate means of hazard reduction. Joint discussions between FEMA and Commonwealth agencies — including the Planning Board, the Department of Natural Resources, the Governor's Office, and Civil Defense — identified four prospective target areas in which to focus hazard mitigation efforts: Loíza and Carolina, Dorado and Toa Baja, Guayanilla, and Humacao.

Following these initial discussions, the Department of Natural Resources assumed the lead in hazard mitigation planning. A Hazard Mitigation Task Force, consisting of representatives of over 20 Commonwealth, municipal and federal agencies, was formed. The Task Force approved a work program that called for development, before the start of the next hurricane season, of a hazard mitigation plan for all of Puerto Rico and hazard mitigation plans for two target areas (coastal floodplain of Ric Grande de Loíza and coastal floodplain of Ric de La Plata). A smaller Hazard Mitigation Work Group was also formed to assist DNR in carrying out the technical work.

Conclusion

In retrospect, Puerto Rico was fortunate that the damage and loss of life from these two storms was not far greater. David caused massive destruction in both Dominica and the Dominican Republic, where there were more than 3,000 storm-related deaths. Only a minor change in the direction of David could have resulted in similar devastation in Puerto Rico. Frederic began as a minor hurricane, but was downgraded to a tropical storm before hitting Puerto Rico. Later, it returned to hurricane force and was one of the most intense hurricanes to strike the U.S. Gulf Coast in this century, causing billions of dollars in damages.

David and Frederic caused many millions of dollars in damages in Puerto Rico. Current estimates place total damages at over \$\\$ million. Seven deaths were also attributed to the storms. Yet, preliminary, unofficial estimates by the Corps of Engineers indicate that most of the flooding which occurred was only equivalent to about a 10-year frequency. Some areas, however, received flooding at approximately a 40- or 50-year level. The extensive damage that occurred -- and the need to declare 72 municipios disaster areas -- resulted primarily because the floods affected almost every part of the island. Extensive agricultural losses also occurred -- exceeding \$50 million -- primarily from wind damages. Yet, winds that actually affected Puerto Rico were generally below hurricane force, with gusts exceeding 75 mph in only a few areas.

Recognition that these damages resulted from strong, but not devastating, storms is important to understanding the vast potential damage to which Puerto Rico is subject. With this potential in mind, it is important to examine the emergency and disaster assistance experience created by David and Frederic with an eye to identifying areas that could be improved. Several areas for improvement are noted below.

Overall, the response to Hurricane David and Tropical Storm Frederic -- from warnings through post-flood recovery -- appeared to be generally good. However, problems were identified in a number of areas.

- Lack of coordination in communications. For example, some television and radio stations reportedly repeated forecasts which were no longer in effect, causing confusion among the listeners. Also, there were some complaints that NWS Bulletins warning of the impending hurricane were made too late.

The Puerto Rico Civil Defense Agency noted that some radio stations did not join its emergency broadcast system.

Emergency procedures of local civil defense authorities were criticized in some areas -- for example, delayed evacuations or lack of necessary supplies.

(This may partially be a problem of lack of awareness by the citizens. In some areas, the civil defense authorities apparently tried to evacuate residents who refused to leave ahead of time, then complained that they had to be rescued from rapidly rising flood waters.)

- There was a real possibility of delays in receiving federal disaster assistance because of overdue accounts from previous disasters. On September 2nd a repayment of \$400,000 for the 1974 disaster was made to the federal government. Also, Puerto Rico owed \$5 million in unused funds from the 1975 flood disaster, a portion of which had to be repaid prior to receiving new disaster funds.
- Some refugees were still being housed in schools more than a week after the second storm, keeping over 3,000 pupils from attending classes. In other cases, although refugees had been moved out, clean-up activities prevented schools from reopening.

(There appears to be some confusion in regard to the types -- and priorities -- of buildings to be used as emergency shelters. As Hurricane David approached, the Secretary of Education reportedly urged that community centers, rather than schools, be chosen as shelters.)

- Squatter communities, in particular, are susceptible to repeated flooding. Partial blame has been attributed to the lack of enforcement of zoning regulations in some areas which allows people to build in uninhabitable areas. The Civil Defense Agency suggested that destruction of these susceptible squatter villages may be the only way to prevent families from returning and rebuilding their homes in hazardous areas.

- Delays in the temporary housing program -- particularly in verifying applications for eligibility -- were attributed to a lack of management capability and insufficient staff to handle the large number of claims. Reorganization and the hiring of additional support staff apparently improved these problems in one application process.

 Another related problem, however, involves Puerto Rico housing law. Apparently, many private landlords were reluctant to sign 3-month leases for temporary housing, since a tenant's inability to pay rent after that time can cost the owner six months or more income due to laws that make it difficult to evict tenants for nonpayment of rent.
- Delays in initiation of the hazard mitigation effort occurred probably due to the newness of the requirement. Neither federal nor Puerto Rico officials were prepared in advance to respond to requirements for hazard mitigation. FEMA did not provide guidance on specific requirements for the hazard mitigation activities, and a lead Commonwealth agency to be responsible for the effort was not immediately identified.



MAPS SHOWING REGULATED COASTAL \updelta , FLOOD PLAIN

ART COVER BY JUAN F, DELGADO